KYOTO UNIVERSITY

PUBLICATIONS OF THE SETO MARINE BIOLOGICAL LABORATORY

Volume IX

KYOTO UNIVERSITY
SETO MARINE BIOLOGICAL LABORATORY
SIRAHAMA

Sirahama, Wakayama-ken, Japan
Published by the Laboratory
1961

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ON THE POSSIBLE SEGREGATION FOUND IN THE COPEPOD FAUNA IN THE DEEP WATERS OFF THE SOUTH-EASTERN COAST OF JAPAN[1,2] (JEDS-3)

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With 3 Text-figures and 5 Tables

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I. Introduction

The present study based on a large collection of pelagic copepods from the deep waters off the south-eastern coast of Japan is planned to explain the differences found in the pelagic copepod fauna between the eastern and western deep waters separated from each other by the submarine ridge stretching southwards from the end of Izu Peninsula including the Ogasawara (=Bonin) Islands on its way (Fig. 1). This ridge is hereafter referred simply as "the Ridge".

Many samples have been collected in the deep waters of the Kuroshio region west of the Ridge by the Kōbe Marine Observatory since 1954. The author has examined 17 of them which came from 250 m–2000 m layers and some results obtained were reported in papers written by Matsudaira and the present author (Matsudaira & Furuhashi, 1955, 1960). In addition to these, eight more collec-

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1) JEDS Contribution No. 20.
2) Contribution from the Kōbe Marine Observatory.

Publ. Seto Mar. Biol. Lab., IX (1), 1961. (Article 1)

tions were made by divided hauls in the layer from 2500 m to the surface of the same region in autumn of 1960. All the data obtained from the above-mentioned samples are to be used to explain the nature of the water mass being constituted of the warm water of the Kuroshio and the cold water forming a cyclonic vortex to the west of the Ridge.

On the other hand, in the cold Oyashio Current many hydrographical and biological observations have been made up to this day, but the collections from the deep water have scarcely been made. In the summer of 1957, however, I.G.Y. Observations worked in this region and the author had a chance to make two vertical hauls respectively from 600 m and 100 m to the surface. Copepods in these samples were fully identified and shown in Table 4 to be compared with those in the Kuroshio region. Besides, there are a few samples from the deep water of the Kuroshio region east of the Ridge. Namely, through the courtesy of Dr. MARUMO, the author had fortunately a chance to participate in the Third Japanese Expedition of Deep Sea (**JEDS-3**) on board the R.M.S. "Ryōfū Maru" and to examine a plankton sample collected by horizontal towing at the 1000 m layer. This seems to be very useful to explain the state of the Kuroshio east of the Ridge.

The deep-sea copepod fauna west of the Ridge was then compared very carefully with that east of the Ridge, and this shows the possibility of the deep-sea copepod fauna being segregated between the east and west sides of the Ridge. This is considered to be a very significant finding, since some new explanation will be needed as to the structure of the deep waters off the south-eastern coast of Japan, if the trend shown in this paper is definitely ascertained.

Before going further, the author wishes to express his hearty thanks to Dr. Yasuo MATSUDAIRA, Dr. Otohiko TANAKA and Dr. Takasi TOKIOKA for their kind encouragement and very helpful advices given throughout the present work. It is also a great pleasure to extend his best thanks to Dr. Kōzō HISHIDA and Dr. Ryūzō MARUMO for their kindness guiding the author so generously throughout the present study. He is much indebted to the members of oceanographical section of the Kōbe Marine Observatory and the crew of the R.M.S. "Shunpū Maru" for their assistances in collecting samples.

II. Material and Methods

The present material consists of the collections made at the four stations whose positions are:

Station A	30°40′N,	137°40′E,	1960-XI- 6
Station B	33°00′N,	137°37′E,	1960-X-31
Station C	38°00′N,	145°23′E,	1957-VI-20
Station D	30°01′N,	146°26′E,	1960-V-19

The stations are shown in Fig. 1, together with the bottom contours copied from the Depth Curve Chart of the Adjacent Sea of Japan by the Maritime Safety Agency of Japan (1952).

At St. A, six vertical hauls were made from 2440 m to the surface by divided hauls using a closing net, and at St. B, a single vertical haul was made from 1040 m to 580 m by a closing net. At St. C, two vertical hauls were made respectively from 600 m and 100 m to the surface by a quantitative plankton net. At St. D, horizontal towings were made at several layers by letting the ship drift for two hours, and of these samples the one came from the 1000 m layer was examined. The nets used during the above-mentioned operations have a 51 cm mouth diameter and stretched with the fine bolting silk (GG-54) having about 0.3 mm square meshes.

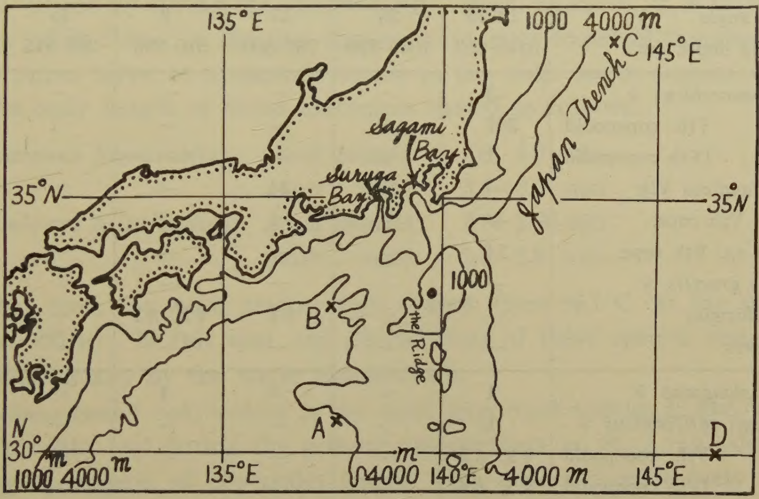

Fig. 1. Map showing the position of four stations together with 1000 m and 4000 m contours in the sea south of Japan.

III. Copepods of the Kuroshio Region West of the Ridge

In the surface layers of the Kuroshio off the southern coast of Japan there occur many tropical and subtropical species, usually up to about 40 species in a single haul. Below the 1000 m layer, however, the copepod fauna is constituted mainly of *Calanus helgolandicus, Eucalanus bungii californicus* and *Rhincalanus nasutus* (Matsudaira & Furuhashi, 1955, '60).

The collection made at St. A was studied in detail as to several genera of copepod and the results are shown in Table 1. The table shows clearly a rather monotonous composition consisting of *Calanus finmarchicus, Eucalanus bungii californicus* and *Rhincalanus nasutus.*

In my previous papers, *Calanus finmarchicus* and *Calanus helgolandicus* had often been treated under a single species, *Calanus helgolandicus*, because the difference between these two species was not clearly understood. Generally, however, two groups are easily separable from each other by size in the "Formenkreis" including these two species as TANAKA (1956b) mentions and the range of vertical distribution of each group is defined rather clearly. The smaller group is considered to represent *Calanus helglandicus*, while the larger

Table 1. Occurrences of deep sea copepods belonging to five genera in respective samples collected at Station A.

Time	23 : 50∼ 00 : 11	21 : 54∼ 22 : 05	22 : 33∼ 22 : 38	23 : 00∼ 23 : 0.4	21 : 00	20 : 45
Wire length (m)	2500–1065	1100–808	800–522	520–256	275–118	110–0
Wire angle (°)	13–26	25	17	9	15	15
Hauled depth (m)	2440–960	1000–730	760–500	510–250	265–115	105–0
Calanus finmarchicus ♀	3	—	—	—	—	—
〃 Vth copepodid	307	6	—	—	1	—
〃 IVth copepodid	1	—	—	—	—	—
Cal. helgolandicus Vth	—	19	44	—	—	—
Cal. minor Vth cope.	—	—	1	2	—	6
Calanoides sp. Vth cope.	14	—	—	—	—	—
Neocalanus gracilis ♀	—	—	—	—	—	2
Undinula darwini	—	—	♀1	♀2, ♂1	—	♀, ♂30
Und. vulgaris	—	—	—	—	—	♀1
Eucalanus elongatus ♀	1	—	3	1	—	—
Eucal. bungii californicus ♀	1	—	—	—	—	—
〃 Vth copepodid	♀9, ♂5	—	—	—	—	—
〃 IVth copepodid	♀5, ♂6	—	—	—	—	—
Eucal. crassus ♀	—	—	—	—	—	1
〃 IIIrd to Vth copepodid	12	—	—	—	—	—
Eucal. mucronatus ♀	—	—	1	1	1	—
Eucal. pileatus ♀	—	—	1	—	—	4
Eucal. misc.	—	—	—	—	3	9
Rhincalanus nasutus	39	21	4	2	—	—
Rhincal. cornutus	1	—	—	1	—	1
Pleuromamma xiphias	♀1	—	♂1	♀2	♂2	♀2, ♂1
Pl. abdominalis	—	—	♀1, ♂1	♀3, ♂1	♀1, ♂1	♀3, ♂3
Pl. robusta	—	—	♀1	—	—	—
Pl. gracilis	—	—	♀4	♀12	♀1	♀6
Metridia curticauda	♀4	♀1, ♂1	♀3	—	—	—
Met. venusta	—	—	♀3, ♂2	—	—	—
Met. brevicauda ♀	2	—	3	—	—	—

one is regarded as corresponding to *Calanus finmarchicus*. In the present material, three groups were defined by the following ranges of body length:

Calanus finmarchicus	adult female	3.65–3.80 mm
" "	Vth copepodid stage	3.0 –3.2 mm
Calanus helgolandicus	Vth copepodid	2.1 –2.5 mm

Three adult females of *Calanus finmarchicus* were found only in the deepest layer surveyed together with many specimens of the Vth copepodid stage. While none of adult specimens of *Calanus helgolandicus* was found at the same station (A), although the specimens of the Vth copepodid stage were found at the layer from 1000 m to 500 m. It can be seen clearly from the data shown in Table 1 that the distributions of these two species were differently limited by the depth in the Kuroshio region. The water temperature ranged from 1.79°C (at 2440 m) to 10.74°C (at 500 m) during the observations. Here, however, it is to be noticed that many adult forms of the two species were ever found in samples collected from the upper layer at a central station in the cold water domain in March, 1958. The body length of these specimens varied as follows:

Calanus finmarchicus	adult female	3.6 –4.0 mm
" "	adult male	3.2 –3.3 mm
Calanus helgolandicus	adult female	2.35–2.90 mm
" "	adult male	2.6 –2.8 mm

At that time, the water temperature ranged from 16.1°C (at the surface) to 12.4°C (at 100 m). In this case, the distributions of these species seemed to be limited superficially by the water temperature.

Eucalanus bungii californicus is the most important species in the deep water of the Kuroshio, and during the present observations at St. A an adult female and many specimens of copepodid stages were collected exclusively from the water layer deeper than 960 m. On the other hand, a considerable number of this species were found in the subsurface water in March and May, 1960. Nevertheless, it seems very probable that the majority of this species live in the deeper water of the Kuroshio region.

Rhincalanus nasutus was found in the layer from 2440 m to 250 m, the majority being confined to the deepest layer surveyed.

Although, four species of *Pleuromamma* appeared rather in upper layers than in deeper waters during the present observations, this does not show that the species are the inhabitants of the shallow water, since the forms belonging to this genus show a very striking diurnal migration in the Kuroshio region as shown below. As the samples were collected at St. A at night from 20:45 to midnight on November 6th, it is not strange that a number of *Pleuromamma* were met in the shallower layers. Many pelagic copepods are known to show a diurnal migration, the range of migration seems, however, to be less than one hundred meters in the Kuroshio region. But, the species belonging to the genus *Pleuromamma* are considered to migrate diurnally for the range of one hundred meters or more. For this reason, *Pleuromamma* spp. had better be excluded out of the general discussion of the vertical distributions of deep-sea copepods.

Three species of *Metridia* were found only in the layers deeper than 500 m. The similar distribution had already been known in previous studies, although *Metridia longa* and *Met. lucens* has never been found in the Kuroshio region west of the Ridge.

IV. Diurnal Migration of *Pleuromamma*

There are few studies on *Pleuromamma* in the Northwestern Pacific. Only MOTODA and ANRAKU (1955) state briefly that *Pleuromamma* was not found in any samples collected in the daytime from the layers upper than 64 m in the Kuroshio region because of its preference of comparatively deep-water.

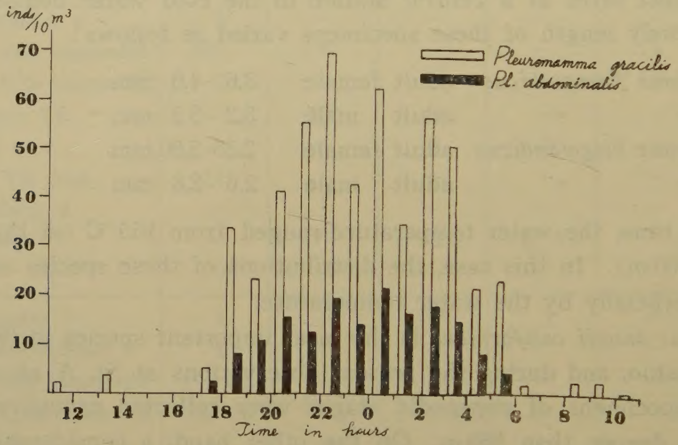

Fig. 2. Occurrences of *Pleuromamma gracilis* and *P. abdominalis* in the sea south of Honshū Island, Japan.

More than 500 vertical hauls from 100 m to the surface were made in the waters off the southern coast of Japan by the R.M.S. "Shunpū Maru" of the Kōbe Marine Observatory during the period from May, 1954 to August, 1958 (Oceanographical section, K.M.O., 1955–'60). In this surveyed area, there was a cold water domain near the coast and the Kuroshio made a detour around its southern edge. The horizontal gradient of the water temperature was generally smaller than the vertical one in the water upper than 100 m and the towings were made for 100 m in wire length, so that the effect of the water temperature may be disregarded for different stations. Examinations were made on *Pleuromamma gracilis* and *P. abdominalis* found in those samples. Mean individual number per 10 m^3 appeared in every hour was calculated in each species and plotted in Fig. 2. Though the number of collections made in every hour fluctuates from 17 at midnight to 34 at noon, the trend shown in Fig. 2 may be safely accepted without any correction. The figure shows evidently that there occur few animals in the daytime, but they increase rapidly after the sunset. The maximum is seen at midnight and then they decrease towards the dawn. The previous data show that these species are distributed chiefly in the layer from 700 m to 100 m and occur most abundantly in the layer from 200 m to 100 m in the daytime. It seems very possible that these animals migrate at least one hundred meters in six hours, or they can travel vertically about 30 cm in a minute.

V. Copepods of the Cold Water Region West of the Ridge

Several vertical hauls have been made from 1000 m or more to the surface in the cold water region off the southern coast of Japan west of the Ridge. And the examination of these samples revealed that the differences found between the vertical distribution of copepods in the cold water region and that in the Kuroshio making a detour around the southern edge of the region might be caused by the upwelling of the deep water of the cold water region (MATSUDAIRA & FURUHASHI, 1960).

Table 2. List of species collected at St. B by a vertical haul from 1040 m to 580 m.

GYMNOPLEA			
Calanus finmarchicus (GUNNERS) ♀	1	*Scolecithricella dentata* (GIESBRECHT) ♀	1
〃 V th copepodid	19	*Scol. propinqua* SARS ♀	1
Cal. minor (CLAUS) V th cope.	1	*Scol. emarginata* FARRAN ♀	1
Cal. helgolandicus (CLAUS)	13	*Metridia curticauda* GIESBRECHT ♀	2
Calanoides sp. V th copepodid	3	*M. brevicauda* GIESBRECHT ♀	1
Eucalanus attenuatus (DANA)	♀ 2, ♂ 3	*Lucicutia ovalis* WOLFENDEN ♀	1
Eucal. elongatus (DANA)	♀ 1, ♂ 1	*Luc. flavicornis* (CLAUS) ♀	1
Eucal. bungii californicus JOHNSON		*Luc. wolfendeni* SEWELL ♂	1
IV th copepodid ♀	1	*Heterorhabdus vicinus* TANAKA ? ♀	1
V th copepodid ♂	1	*Phyllopus helgae* FARRAN ♀	2
Eucal. crassus GIESBRECHT	♀ 6, ♂ 4	*Labidocera acuta* (DANA) ♀	1
Eucal. pileatus GIESBRECHT ♀	1	*Acartia danae* GIESBRECHT ♀	4
Rhincalanus nasutus GIESBRECHT ♀, ♂	26	*Acar. negligens* DANA ♀	2
Paracalanus aculeatus GIESBRECHT ♀	1		
Clausocalanus arcuicornis (DANA) ♀	1	PODOPLEA	
Spinocalanus abyssalis GIESBRECHT ♀	5	*Mormonilla phasma* GIESBRECHT ♀	11
Spinocal. spinosus FARRAN ♀	8	*Oithona plumifera* BAIRD ♀	1
Spinocal. magnus WOLFENDEN ♂	1	*Oith. similis* CLAUS ♀	1
Monacilla typica SARS ♀	1	*Aegisthus aculeatus* GIESBRECHT ♀	1
Aetideopsis multiserrata WOLFENDEN ♀	1	*Oncaea venusta* PHILIPPI	6
Gaetanus sp. ♀	1	*On. conifera* GIESBRECHT	2
Undeuchaeta plumosa (LUBBOCK) ♀	1	*Conaea rapax* GIESBRECHT	♀ 15, ♂ 12
Scaphocalanus sp. ♀	1		

In the sample collected at St. B, thirty-three species of Gymnoplea and 7 species of Podoplea were identified, as they are listed in Table 2 together with their individual numbers found in that haul.

No conspicuous differences are found between the composition of the copepod fauna given above and that seen in the Kuroshio region. Most species collected from the cold water region seem to be abyssal forms, although some of them are found in the surface water of the region, too. And all of these species were also found actually in deep water samples from the Kuroshio region.

VI. Copepods from the Kuroshio Region East of the Ridge

The author has hardly been able to find any studies of deep-water copepods in the Kuroshio region off the south-eastern coast of Japan east of the Ridge. The results of the examination of a sample collected by the R.M.S. "Ryōfū Maru" at St. D in the JEDS-3 Cruise is shown in Table 3, in which 29 species of Gymnoplea and 5 species of Podoplea were identified.

The comparison of this table with Tables 1 and 2 shows the following significant facts:

1. Both adult and immature females of *Calanus finmarchicus* are abundant and predominate over others in the sample from the station, while *Calanus helgolandicus* is quite missing.

Table 3. List of species collected by a horizontal haul at the depth of 1000 m at St. D off the south-eastern coast of Japan.

GYMNOPLEA	
Calanus finmarchicus (GUNNERS) ♀	284
〃 V th copepodid	1743
Cal. cristatus KRÖYER imm. ♀	1
Megacalanus princeps WOLFENDEN ♀	1
Eucalanus elongatus (DANA) ♀	1
Eucal. bungii bungii JOHNSON ♀ 1, ♂	1
Eucal. bungii californicus imm. ♀	1
Rhincalanus nasutus GIESBRECHT ♂	1
Clausocalanus arcuiccrnis (DANA) ♀	20
Monacilla typica SARS ♀	2
Gaetanus kruppi GIESBRECHT ♀ 2, imm. ♂	1
Chirundina streetsi GIESBRECHT ♀	27
Undeuchaeta major GIESBRECHT ♀ 26, ♂	3
Und. plumosa (LUBBOCK) ♀	1
Pareuchaeta confusa TANAKA ? ♀	1
Par. tonsa (GIESBRECHT) ♀	2
Par. comosa TANAKA ♂	1
Par. juv.	10
Lophothrix frontalis GIESBRECHT ♀	2
Scaphocalanus sp. ♀	1
Metridia curticauda GIESBRECHT ♀	3
Met. venusta GIESBRECHT ♀	1
Met. princeps GIESBRECHT ♀ 4, ♂	2
Met. brevicauda GIESBRECHT ♀	1
Met. juv.	5
Pleuromamma xiphias GIESBRECHT ♂	1
Lucicutia curta FARRN ♀	1
Isochaeta ovalis GIESBRECHT ♂	1
Heterorhabdus dubius TANAKA ♀	1
Het. abyssalis GIESBRECHT ♂	1
Het. robustus FARRAN ♂	1
Arietellus simplex SARS ♀	2
PODOPLEA	
Mormonilla phasma GIESBRECHT ♀	40
Mor. minor GIESBRECHT ♀	10
Oithona plumifera BAIRD ♀	90
Oncaea venusta PHILIPPI ♀, ♂	100
Conaea rapax GIESBRECHT ♀	100

2. An immature *Calanus cristatus*, and a female and a male of *Eucalanus bungii bungii* are found. *Eucalanus bungii californicus* and *Rhincalanus nasutus* are also found, but each represented by only a single individual.

3. A female specimen of *Megacalanus princeps* was obtained; this species had been recorded from both Sagami and Suruga Bays by TANAKA (1956a), but never been found from the deep water west of the Ridge.

4. Great numbers of *Chirundina streetsi* and *Undeuchaeta major* were obtained, while they are rather scarce in the Kuroshio region west of the Ridge.

5. A male of *Isochaeta ovalis* was obtained, this had been recorded by TANAKA from Sagami Bay.

The hydrographic condition at St. D was very similar to that in the west of the Ridge, as is seen clearly in Fig. 3 which gives the diagrams of vertical distributions of the water temperature at Stations A, B and D. It can be seen easily from this figure that the differences of the water temperature between the Kuroshio region west of the Ridge and that east of the Ridge is less than the difference found between the Kuroshio region and the cold water region west of the Ridge.

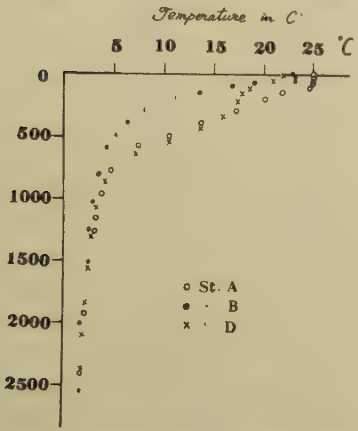

Fig. 3. Vertical distribution of the water temperature at Stations A, B and D off the southern coast of Japan.

VII. Copepods of the Oyashio Region

Although there are many hydrographical and biological studies of the Oyashio Current which are considered to be enough so that the nature of the upper water can be easily compared with that of the midwater, two samples respectively hauled from 100 m and 600 m to the surface at St. C were examined exactly and the detailed results of identification of copepods are shown in Table 4.

Only 10 species of Gymnoplea and 3 species of Podoplea occurred in the upper water sample, while 26 species of Gymnoplea and 6 species of Podoplea were found in the other sample hauled from 600 m to the surface. In the Oyashio region, adults of certain copepods occur usually in the deep water, whereas immature individuals of the same species are found only in the upper water. In the present examined samples, this tendency was observed especially distinctly in *Calanus helgolandicus*, *Calanus plumchrus*, *Eucalanus bungii bungii*, *Eucal. bungii californicus* and *Metridia lucens.* Neither adults nor immature specimens of *Calanus cristatus*, *Pareuchaeta elongata* (=*Par. japonica* MORI) and *Pseudocalanus gracilis* were found in the upper water sample, although these

Table 4. Individuals of respective copepods collected at Station C in the Oyashio region.

Species / Depth	0–100 m	0–600 m
Calanus finmarchicus (GUNNERS) III rd cope.	—	8
Cal. helgolandicus (CLAUS)	♀40, ♂8	♀56
” V th copepodid	96	168
” IV th copepodid	28	—
” III rd copepodid	31	—
Calanus plumchrus MARUKAWA	—	♀3, ♂10
” V th copepodid (4.5 mm–4.8 mm)	112	30
(4.1 mm–4.2 mm)	32	45
” IV th copepodid	44	65
” III rd copepodid	4	24
Cal. cristatus KRÖYER V th copepodid	—	14
” IV th copepodid	—	1
Cal. tenuicornis (DANA)	340	144
Cal. juv.	450	608
Eucalanus bungii bungii JOHNSON	—	♀24
” V th copepodid	—	♀14, ♂10
” IV th copepodid	♂4	♀80, ♂48
” III rd copepodid	878	1224
” II nd copepodid	1244	1968
” I st copepodid	240	80
Eucal. bungii californicus JOHNSON	—	♀1
” IV th copepodid	8	—
” III rd copepodid	4	—
Eucal. crassus GIESBRECHT V th copepodid	4	—
Paracalanus parvus GIESBRECHT	♀570, ♂150	♀4760, ♂440
Clausocalanus pergens FARRAN	—	♀280
Ctenocalanus vanus GIESBRECHT	—	♀80
Pseudocalanus minutus (KRÖYER)	♀, ♂994	adult ♀160, V th cope. 40 ♂1
Pseudocal. gracilis SARS V th copepodid	—	♀600, ♂520
Aetideus armatus (BOECK)	—	♀2, ♂2
Pareuchaeta elongata (ESTERLY)	—	♀2, ♂1
” V th copepodid	—	♀5, ♂1
Par. juv.	—	♀12
Scolecithricella ovata (FARRAN)	—	♀16
Scol. emarginata FARRAN	—	48
Metridia princeps GIESBRECHT V th copepodid	—	♀1
Met. longa LUBBOCK	—	♀23
” V th copepodid	—	♀41, ♂24
Met. lucens BOECK	—	♀256, ♂240
” V th copepodid	♀156, ♂116	♀1216, ♂1016
Met. juv.	3900	7240
Pleuromamma abdominalis (LUBBOCK)	—	♀2, ♂2
Pl. xiphias GIESBRECHT	—	♀1
Pl. sp.	—	♀10, ♂16
Heterorhabdus devius TANAKA	—	♀1
Heterostylites longicornis (GIESBRECHT)	—	♀2
Candacia bipinnata (GIESBRECHT)	♂4	—
Can. norvegica BOECK	—	♀1
Can. juv.	4	—
Acartia clausi GIESBRECHT	♀120, ♂30	♀, ♂480
Acar. juv.	—	120
Gymnoplea juv.	210	2584
PODOPLEA		
Oithona plumifera BAIRD	♀690	♀1760
Oith. similis CLAUS	♀180	♀3320, ♂240
Oncaea venusta PHILIPPI	—	♀80
On. media GIESBRECHT	—	♀160
On. conifera GIESBRECHT	—	♀40, ♂40
Sapphirina nigromaculata CLAUS	4	—
Sapph. juv.	4	—
Corycaeus affinis MCMURRICH	♀420, ♂1140	♀920, ♂880
Cor. juv.	150	2440

specimens occurred in the deeper water sample. Comparing Table 4 with Tables 1 and 2, the following five points may be perceived:

1. Only the third copepodid stage of *Calanus finmarchicus* was found in the deeper water sample, while many *C. helgolandicus* were found in both upper and deeper water samples; the adult female of the latter was 2.8–3.0 mm in body length.

2. Many *Calanus plumchrus* occurred in both upper and deeper water samples, and the fifth copepodid stage of this species was divided into two groups respectively characterized by 4.5–4.8 mm and 4.1–4.2 mm body length.

3. KITOU states that the adults of *Eucalanus bungii bungii* appeared in the shallow 15–40 m layer in the Oyashio region (MARUMO, KITOU & OHWADA, 1958), but in the present materials, no adults were found in the upper water sample. Both the adults and individuals of all copepodid stages occurred abundantly only in the sample from 600 m to the surface, and it is very noteworthy that the 2nd basal joint of the mandible is already provided with three setae even in the first copepodid stage in these examined specimens. *Eucalanus bungii californicus* were also found in the materials, though they were very scarce.

4. Considerable numbers of *Pseudocalanus minutus*, *P. gracilis*, *Pareuchaeta elongata*, *Metridia longa* and *Met. lucens* occurred in these samples, although they have never been found in the water west of the Ridge.

5. Both females and males of *Corycaeus affinis* (=*Cor. japonicus* MORI) were abundant in samples and the occurrence seemed to be confined to the water layer upper than 100 m. A few specimens of this species can be seen in the surface water of the Kuroshio, but they are quite rare as compared with other species belonging to the same genus.

VIII. Discussion on the Differences between the Copepod Distribution West of the Ridge and That East of the Ridge

So far as the data presented in the preceding chapters are concerned, some distinct differences are perceived clearly between the copepod fauna west of the Ridge and that east of the Ridge. For example, the occurrence of thirteen representatives are given in Table 5.

The first column of the table is filled with data quoted from MORI's work (1937) covering nearly all surface-living pelagic copepods of Japanese waters, records of the 13 species in the Kuroshio region west of the Ridge and those in the Oyashio region east of the Ridge are shown. The middle column shows the data quoted from TANAKA's comprehensive works on Gymnoplea from the Izu region which includes two prominent bays, Suruga Bay in the west and Sagami Bay in the east, these respectively represent topographically the northernmost parts of the regions west and east of the Ridge. And the last one comprises the summaries of the data given in this paper. This table shows the following five significant trends:

1. All these 13 species have never been recorded from the surface water of the Kuroshio.

2. Seven of them, *Calanus plumchrus*, *Cal. cristatus*, *Eucalanus bungii bungii*, *Pareuchaeta elongata*, *Pseudocalanus minutus*, *Metridia longa* and *Met. lucens* have never been found in either the surface- or deep-water west of the Ridge.

Table 5. The occurrences of 13 representatives of the deep sea copepods.

<table>
<tr><th rowspan="3">Observers & area
Species</th><th colspan="2">MORI</th><th colspan="2">TANAKA</th><th colspan="4">FURUHASHI</th></tr>
<tr><th rowspan="2">Kuroshio (West of the Ridge)</th><th rowspan="2">Oyashio (East of the Ridge)</th><th rowspan="2">Suruga Bay (West)</th><th rowspan="2">Sagmi Bay (East)</th><th colspan="2">West of the Ridge</th><th colspan="2">East of the Ridge</th></tr>
<tr><th>Kuroshio</th><th>Cold water</th><th>Kuroshio</th><th>Oyashio</th></tr>
<tr><th></th><th colspan="2">Surface-water</th><th colspan="2">Deep-water</th><th colspan="2">Deep-water</th><th colspan="2">Deep-water</th></tr>
<tr><td>*Calanus finmarchicus*</td><td>–</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td></tr>
<tr><td>*Cal. plumchrus*</td><td>–</td><td>+</td><td>–</td><td>+</td><td>–</td><td>–</td><td>–</td><td>+</td></tr>
<tr><td>*Cal. cristatus*</td><td>–</td><td>+</td><td>–</td><td>+</td><td>–</td><td>–</td><td>+</td><td>+</td></tr>
<tr><td>*Eucalanus bungii bungii*</td><td>–</td><td>+</td><td colspan="2">+</td><td>–</td><td>–</td><td>+</td><td>+</td></tr>
<tr><td>*E. bungii californicus*</td><td>–</td><td>–</td><td>+</td><td>–</td><td>+</td><td>+</td><td>+</td><td>+</td></tr>
<tr><td>*Pseudocalanns minutus*</td><td>–</td><td>+</td><td>–</td><td>+</td><td>–</td><td>–</td><td>–</td><td>+</td></tr>
<tr><td>*Pareuchaeta elongata*</td><td>–</td><td>+</td><td>–</td><td>+</td><td>–</td><td>–</td><td>–</td><td>+</td></tr>
<tr><td>*Metridia curticauda*</td><td>–</td><td>–</td><td colspan="2">+</td><td>+</td><td>+</td><td>+</td><td>–</td></tr>
<tr><td>*Met. venusta*</td><td>–</td><td>–</td><td colspan="2">+</td><td>+</td><td>+</td><td>+</td><td>–</td></tr>
<tr><td>*Met. brevicauda*</td><td>–</td><td>–</td><td colspan="2">+</td><td>+</td><td>+</td><td>+</td><td>–</td></tr>
<tr><td>*Met. princeps*</td><td>–</td><td>–</td><td colspan="2">+</td><td>+</td><td>+</td><td>+</td><td>+</td></tr>
<tr><td>*Met. longa*</td><td>–</td><td>–</td><td colspan="2">+</td><td>–</td><td>–</td><td>–</td><td>+</td></tr>
<tr><td>*Met. lucens*</td><td>–</td><td>+</td><td colspan="2">+</td><td>–</td><td>–</td><td>–</td><td>+</td></tr>
</table>

3. Of the above-mentioned seven species, *Cal. cristatus* and *Eucalanus bungii bungii* were found in the sample collected from the deep water of the Kuroshio region east of the Ridge.

4. All these 13 species were found in some of the samples collected in the regions east of the Ridge.

5. There is practically no difference about the occurrence of respective species between the cold water region and the Kuroshio region west of the Ridge.

It is a very noticeable fact that the difference of the deep-sea copepod fauna between Suruga and Sagami Bays is quite parallel to that found between the Kuroshio and the cold water regions west of the Ridge and the Kuroshio and the Oyashio regions east of the Ridge. These two bays are located side by side, being less than 40 miles apart. And TANAKA's collections were made chiefly by the towing from 1000 m to the surface during the years 1936–1940. ICHIYE (1957) states that a cyclonic vortex west of the Ridge was observed during 1936–1944 and again it appeared since 1954. The results of a serial hydrographic observations carried by the Kōbe Marine Observatory since 1954 show that the Kuroshio makes a detour around a cyclonic vortex to the south and then along the west of the Ridge to the north, and then flows eastward over the Ridge south of Izu Peninsula. Therefore, the upper water of two bays are to be considered as the tropical or subtropical water. Under such oceanographical conditions, the segregation found in the deep-sea copepod fauna between the areas west and east of the Ridge can be explained only when the cold-water species maintained in the Western North Pacific Central Water are distributed under the Kuroshio east of the Ridge. As seen in Fig. 1, a wedge-shaped 1000 m contour goes deeply into the heart of Sagami Bay connecting it with the Japan Trench, while the trough in Suruga Bay is separated from the trough in Sagami Bay and the Japan Trench by the Ridge. On the other hand, according to ICHIYE's calculation (ICHIYE, 1960) the water shows the motionless state at 1000 m–1200 m in the whole area of the Kuroshio. Thus, it is very probable that the Oyashio can mingle with the deep water of Sagami Bay, but not with that of Suruga Bay.

Here it must be remembered that the composition of copepod fauna in the cold water region west of the Ridge resembles closely that in the Kuroshio region of the same area. For this reason, it is very possible that the water mass of the cold water region is quite the same as the deeper water mass of the Kuroshio region west of the Ridge.

ICHIYE published a very interesting theory concerning the variation of the Kuroshio pointing out the importance of the deep current and the submarine ridge south of Japan; according to this the cold water domain west of the Ridge is nothing but the upwelled deep water piled up by the counter current under the Kuroshio deflected to the north by the Ridge (ICHIYE, 1960). However, to satisfy this theory it seems necessary to demonstrate the existence of some Oyashio-living animals in the deeper water, so-called submerged counter current under the Kuroshio west of the Ridge.

Although much more detailed observations are needed to give the definite conclusion concerning the occurrence of the cold water domain and to clarify the nature of the counter current under the Kuroshio west of the Ridge, the complete absence of any Oyashio-living animals in both the surface and deep water west of the Ridge seems to offer a very important and significant clue to this problem. Anyhow, it seems very doubtful that the deeper water under the Kuroshio west of the Ridge and the submerged Oyashio water can be defined under a single name of the Western North Pacific Central Water.

IX. Summary and Conclusions

1. The effect of the Bonin Ridge on the distribution of deep-sea copepods in the deep waters off the south-eastern coast of Japan is discussed and this seems to urge further studies on the biogeographical effect of the Ridge upon the plankton animals in the deep waters in this area. The Ridge seems to prevent the invasion of the Oyashio-living copepods maintained in the submerged water to the sea west of the Ridge. On the other hand, the Kuroshio carries the surface-living tropical or sub-tropical copepods to the sea east of the Ridge even to the cold Oyashio region over the Ridge.

2. *Calanus plumchrus*, *Cal. cristatus*, *Eucalanus bungii bungii*, *Pareuchaeta elongata*, *Pseudocalanus minutus*, *Metridia longa* and *Met. lucens* of Oyashio-living species have never been found in the sea west of the Ridge, although these species were found in the deeper water samples from the Kuroshio region east of the Ridge.

3. The water mass of the cold water domain forming a cyclonic vortex off the southern coast of Japan is considered to belong to the same water mass as that of the deeper layer of the Kuroshio region west of the Ridge because of the biological proof based upon the studies on the distribution of deep sea copepods.

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ON THE DISTRIBUTION OF CHAETOGNATHS IN THE WATERS OFF THE SOUTH-EASTERN COAST OF JAPAN[1,2] (JEDS 3)

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With 11 Text-figures and 1 Table

Introduction

The difference found in the deep water copepod fauna between the areas west and east of the submarine ridge stretching southwards from the end of Izu Peninsula including the Ogasawara Islands on its way was discussed in the previous paper of the present author. In a hope to ascertain whether a similar difference can be seen in the chaetognath fauna or not, the data got from a large collection of chaetognaths made in the deep waters off the south-eastern coast of Japan are treated here in reference to the nature of the water masses west and east of the Ridge mentioned above.

Since 1954, many plankton samples have been collected from the subsurface waters of the Kuroshio region west of the Ridge by the Kōbe Marine Observatory and the author examined those which came from the 0–100 m layer, some results obtained were already published in the previous paper (FURUHASHI, 1959). In addition to these, nine more collections were made by divided hauls in the layer from 2500 m to the surface in the same region in the years 1958–'60. And in the summer of 1957, the I. G. Y. Observations worked in the cold Oyashio region and the author had a chance to make two vertical hauls respectively from 600 m and 100 m to the surface. The results of the close examination on these samples together with those on the preceding collection made by the Kōbe Marine Observatory are embodied in the present paper.

The distinction between the deep water chaetognath faunas west and east of the Ridge does not seem so remarkable as in the case of copepods. However, the present work may be considered to be significant in that it shows roughly the outline of the vertical distribution of respective species in the Japanese waters, about which very little has been known.

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1) JEDS Contribution No. 17.
2) Contribution from the Kōbe Marine Observatory.

Publ. Seto Mar. Biol. Lab., IX (1), 1961. (Article 2)

At the same time, the results here published together with the data obtained from the extensive observations made by the Kōbe Marine Observatory show the differentiation of the chaetognath fauna found between the inshore and offshore waters off the Pacific coast of middle Japan, the exact feature about this have not yet been cleared, either.

Before going further, the author wishes to express his hearty thanks to Dr. Takasi TOKIOKA of the Seto Marine Biological Laboratory for his kind encouragement and very helpful advices given throughout the present work. He is also much indebted to the members of oceanographical section of the Kōbe Marine Observatory and the crew of the R. M. S. "Shunpū Maru" for their assistance in collecting samples.

Material and Method

The present material consists of six collections made at stations whose positions are shown in Fig. 1 and in Table 1. In the area west of the Ridge, six vertical hauls were made at St. A from 2440 m to the surface by divided hauls using a closing net and a single vertical haul was made from 1040 m to 580 m with a closing net at St. B. Besides these, a single vertical haul was made at Sts. I4 and G4 respectively from 920 m and 1080 m to the surface with a closing

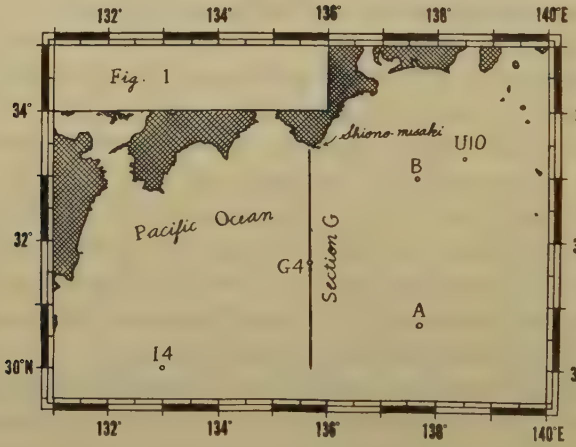

Fig. 1. Map showing the position of five stations and the Section G in the area west of the Ridge surveyed by the Kōbe Marine Observatory. Readers may feel strange at that St. A in the Kuroshio area, while Stations I4 and G4 are in the far offshore water beyond the Current of Kuroshio. This is because the Kuroshio changes the course from time to time and the collections were made at respective station in different seasons of different years.

Table 1. Occurrence of chaetognaths in respective samples collected at 7 stations in the sea off the south-eastern coast of Japan. (* from MATSUDAIRA & FURUHASHI, 1955).

Area	West of the Ridge										East of the Ridge		
	Kuroshio region						Far offshore water beyond the Kuroshio		Cold water region		Oyashio region		Kuroshio region
Station	A						I4	G4	B	U10*	C		D
Location Lat. (N) Long. (E)	30–40 137–40						30–00 133–00	31–40 135–40	33–00 137–37	33–17 138–28	38–00 145–23		30 01 146–26
Date	Nov., 6∼7, 1960						July, 3, 1958	Aug., 5, 1958	Oct., 31, 1960	Sep., 2, 1954	June, 20, 1957		May, 19, 1960
Time	20 : 45	21 : 00	23 : 00– 23 : 04	22 : 23– 22 : 38	21 : 54– 22 : 05	23 : 50– 00 : 11	13 : 20– 14 : 00	06 : 30	19 : 40– 19 : 49	23 : 25–	08 : 60	09 : 42	08 : 29– 10 : 30
Hauled distance (m) Wire angle Hauled depth (m)	0–110 16 0–106	118–275 15 115–265	256–520 9 250–510	522–800 17 500–760	808–1100 25 730–1000	1065–2500 13–26 960–2440	0–1300 45 0–920	0–1100 10 0–1080	630–1300 22–37 585–1040	1300–2000 5–14 1300–1940	0–100 30 0–85	0–600 42 0 445	 1000
Sagitta hexaptera D'ORBIGNY	4	1	1	—	—	—	15	14	—	—	—	—	—
S. lyra KROHN	—	3	3	—	—	—	35	19	—	—	—	1	2
S. enflata GRASSI	52	2	1	—	—	—	56	7	—	—	—	—	—
S. bipunctata QUOY *et* GAIMARD	1	—	—	1	—	—	4	4	—	—	—	—	—
S. ferox DONCASTER	—	—	—	—	—	—	1	—	—	—	—	—	—
S. robusta DONCASTER	3	—	—	—	—	—	—	—	—	—	—	—	—
S. bedoti BERNECK	—	—	—	—	—	—	—	—	—	—	124	76	—
S. pulchra DONCASTER	—	—	—	—	—	—	—	4	—	—	—	—	—
S. ser. pacifica TOKIOKA	4	—	—	—	—	—	3	10	—	—	—	—	—
S. ser. atlantica f. *pseudo-serratodentata* TOKIOKA	—	—	—	—	—	—	10	20	—	—	—	—	—
S. regularis AIDA	1	3	—	1	—	—	27	2	—	—	—	—	—
S. neglecta AIDA	2	—	—	—	—	—	2	—	—	—	—	—	—
S. minima GRASSI	—	2	—	—	—	—	34	95	—	—	12	16	—
Pterosagitta draco (KROHN)	11	—	—	—	—	—	31	33	—	—	—	—	—
Krohnitta subtilis (GRASSI)	—	4	3	—	—	—	24	17	—	—	—	—	—
K. pacifica (AIDA)	2	—	—	—	—	—	12	4	—	—	—	—	—
Sagitta elegans VERRILL	—	—	—	—	—	—	—	—	—	—	36	23	—
S. decipiens FOWLER	—	1	1	1	1	—	18	18	1	—	—	1	—
S. planctonis STEINHAUS	—	—	—	1	—	—	2	2	—	1	—	—	2
S. macrocephala FOWLER	—	—	—	—	—	—	—	1	2	—	—	—	—
Eukrohnia hamata (MÖBIUS)	—	—	—	1	—	5	5	6	4	—	—	98	16

net. In the area east of the Ridge, two vertical hauls were made respectively from 600 m and 100 m to the surface at St. C with a quantitative plankton net. At St. D, horizontal towings were made at several layers by letting the ship drift for two hours during the JEDS-3 Cruise and one of these samples collected at the 1000 m layer was examined. The net used during the above-mentioned operations have a 51 cm mouth diameter and is stretched with the fine bolting silk (GG-54) having about 0.3 mm square meshes. The whole contents of every sample were examined and every specimen of chaetognaths was picked out to be identified and recorded. The raw data thus obtained are shown in Table 1.

Distribution of Chaetognaths in Respective Areas

1) *The Kuroshio region west of the Ridge*

In the samples collected at St. A, 15 species belonging to four genera were found. Nine of these species seemed to be warm-water species and were found only in the sample collected from 110 m to the surface, *Sagitta enflata* being the most abundant species of all. These nine species decreased in number with the depth and disappeared completely in samples collected at the level deeper than 730 m. On the other hand, three other species were considered to be abyssal forms and found in the deep-water samples. *Sagitta decipiens* was a widely distributed species in the samples from 115 m to 1000 m, though its occurrence was represented only by a single specimen. In the sample from the deepest layer only *Eukrohnia hamata* was found.

2) *The far offshore waters beyond the Kuroshio region west of the Ridge*

In samples collected at St. I4 and G4, 18 species belonging to four genera were found. Among these, *Sagitta decipiens*, *S. planctonis*, *S. macrocephala* and *Eukrohnia hamata* were considered to be abyssal forms. The compositions at these stations show that the proportion of *Sagitta enflata* to all other warm-water species is much less than that throughout the whole samples at St. A. It is 28% at St. I4 and 3% at St. G4, while it attains 106% at St. A.

The tendency of *S. enflata* towards the decrease was shown by TOKIOKA in the far oceanic water of the Central North Pacific (TOKIOKA, 1959), too.

3) *The cold water region west of the Rdige*

In the sample collected at St. B, there occurred only 3 species, *Sagitta decipiens*, *S. macrocephala* and *Eukrohnia hamata*. Besides, the occurrence of a single specimen of *Sagitta planctonis* in the sample collected from 1940 m to 1300 m at St. U10 in the same region is recorded (MATSUDAIRA & FURUHASHI, 1955). Thus, the composition of chaetognath population in the deep water of the cold water region is quite the same as that in the deep water of the Kuroshio region west of the Ridge.

4) *The Kuroshio region east of the Ridge*

In the sample collected at St. D, only three species were identified. *Eukrohnia hamata* was the most abundant species, while *Sagitta lyra* and *S. planctonis* were rather scarce. Though this composition resembles that found in the Kuroshio regions west of the Ridge, the proportion of *Eukrohnia hamata* seems to be much larger than in the Kuroshio region west of the Ridge.

5) *The Oyashio region*

Three species were found in the sample collected from 100 m to the surface at St. C and *Sagitta bedoti* was the most abundant species of all the three. On the other hand, 6 species were identified in the sample collected from 600 m to the surface and *Eukrohnia hamata* was the most abundant species of these. *Sagitta elegans* occurred commonly in both samples, but this species seems to occur seldom in the deeper water at this station.

General Hydrographical Features in the Waters West of the Ridge

Seventy-six vertical hauls from 100 m to the surface and a series of hydro-

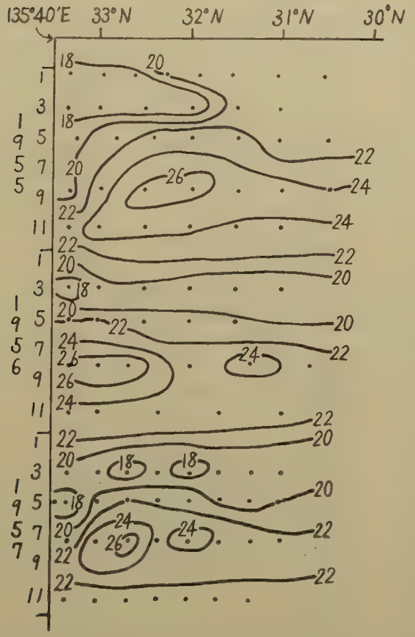

Fig. 2. The seasonal variation of the water temperature (°C) at 50 m layer along Section G south of the cape of Shionomisaki on the Pacific coast of middle Japan during the period from January, 1955 to November, 1957.

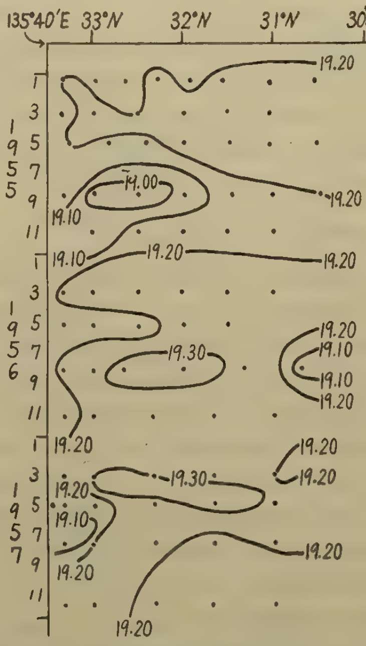

Fig. 3. The seasonal variation of the chlorinity (value in ‰) at 50 m layer along Section G south of the cape of Shionomisaki on the Pacific coast of middle Japan during the period from January, 1955 to November, 1957.

graphical observations were made along Section G in the waters south of the cape of Shionomisaki on the Pacific coast of middle Japan by the R. M. S. "Shunpū Maru" of the Kōbe Marine Observatory during the period from January, 1955 to November, 1957. The seasonal variations of the water temperature and the chlorinity at 50 m layer along this section are shown respectively in Figures 2 and 3.

MORIYASU (1959) states that the cold water region was generally situated north of 32°N off the southern coast of middle Japan and with the westward extention in the beginning of 1955, but the region was generally decayed and occasionally became quite obscure in 1956. The cold water region is shown in Fig. 2 as the extension of a low water temperature (18°C) near the coast in the first half of 1955. Figures 2 and 3 show that the stream centre of the Kuroshio was far apart from the coast in that time, but it has approached to the coast since the summer of 1956.

Distributional Aspects of Respective Species of Chaetognaths

The occurrences of respective species of chaetognaths along Section G during the years 1955 to 1957 are shown in Figures 4–11 which are considered to show the outline of the seasonal fluctuation of respective species of chaetognaths in the Kuroshio region west of the Ridge.

1) *Sagitta hexaptera*

The result of the statistical studies on many samples collected from 100 m to the surface in the waters off the Pacific coast of middle Japan reveals that this species occurs mainly in the far offshore water beyond the Kuroshio, but it is not found in the cold water region (FURUHASHI, 1959).

In the present material a few specimens occurred in the samples collected at the layers shallower than 510 m at St. A in the Kuroshio region west of the Ridge. More abundant specimens were caught in the far offshore water beyond the Kuroshio west of the Ridge (Station I4 and G4). The occurrence of the species along Section G south of the cape of Shionomisaki is shown

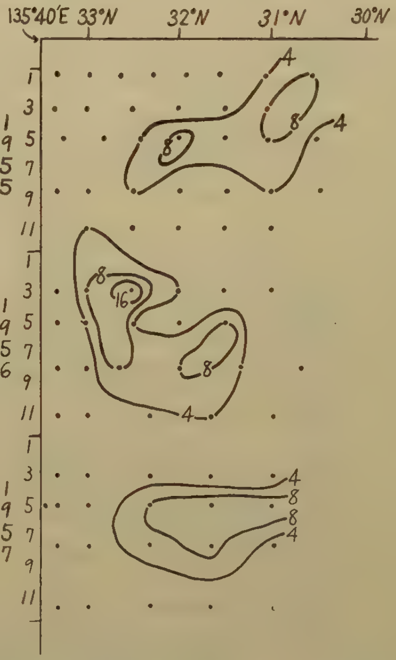

Fig. 4. Individual number of *Sagitta hexaptera* per 10 m^3 along Section G south of the cape of Shionomisaki on the Pacific coast of middle Japan during the period from January, 1955 to November, 1957.

in Fig. 4 which shows that the seasonal fluctuation was not clear and the distribution seemed to be much affected by the strength of respective water masses found in the surveyed area.

2) *Sagitta lyra*

Three specimens were found in each of the samples respectively collected at the layers 250 m–510 m and 115 m–265 m at St. A, while abundant specimens were found in the samples collected at Stations I4 and G4 in the far offshore water of the Ridge. On the other hand, only a single specimen was found in one of the samples collected at St. C in the Oyashio region, this specimen was fully matured and 53 mm long, the maximum of all the specimens in this material.

The distribution of this species seems to trend towards the low water temperature, but this does not mean that the species is common in the cold water in the Pacific. In the surveyed area, this was abundant in the far offshore waters in both areas west and east of the Ridge. Figures 5 and 3 show that the chlorinity of the water of the distributional range of *S. lyra* off the southern coast of middle Japan was higher than 19.20‰.

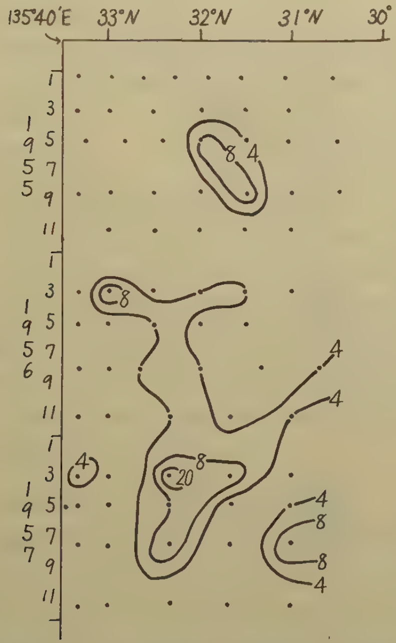

Fig. 5. Individual number of *Sagitta lyra* per 10 m^3 along Section G south of the cape of Shionomisaki on the Pacific coast of middle Japan during the period from January, 1955 to November, 1957.

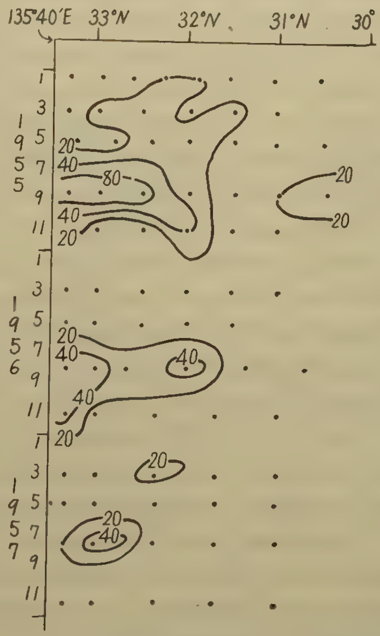

Fig. 6. Individual number of *Sagitta enflata* per 10 m^3 along Section G south of the cape of Shionomisaki on the Pacific coast of middle Japan during the period from January, 1955 to November, 1957.

3) *Sagitta enflata*

This is the commonest species in the Kuroshio region, occurring most abundantly in the subsurface water shallower than 510 m in the present observations. No individual occurred in the Oyashio region.

The occurrence of this species along Section G was shown in Fig. 6, which shows that the species occurred most commonly in August and its maximal densities were observed in the area extending from the stream centre of the Kuroshio to the inshore waters, but the density decreased towards the offshore waters beyond the Kuroshio.

4) *Sagitta bipunctata, S. ferox, S. robusta* & *S. pulchra*

These species are typical tropical water forms and occurred only sparsely in the samples collected in the Kuroshio region and in the far offshore waters west of the Ridge. None of these species were found in the Oyashio water samples.

5) *Sagitta bedoti*

The distributional feature of this species in the Indo-Pacific is reported by TOKIOKA (1959) who states that the water masses containing *S. bedoti* are reasonably separable from far oceanic water masses free from this species and proposes to call the former "*bedoti*-water" after this characteristic indicator. This seems to be applicable to the waters off the southern coast of middle Japan as is shown by the statistical study on the distribution of this species reported in the previous paper of the present author (FURUHASHI, 1959).

The species also indicates clearly the existence of the cold water mass in the East China Sea (FURUHASHI, 1958).

In the Japan Sea, this is the dominant species along the warm Tsushima current, but it decreases with the depth, being replaced by *S. elegans*, and quite disappears in the samples collected at layers deeper than 250 m (FURUHASHI, 1953).

In the present material, this species was found commonly in samples collected in the Oyashio region, but quite missing in samples collected in the area west of

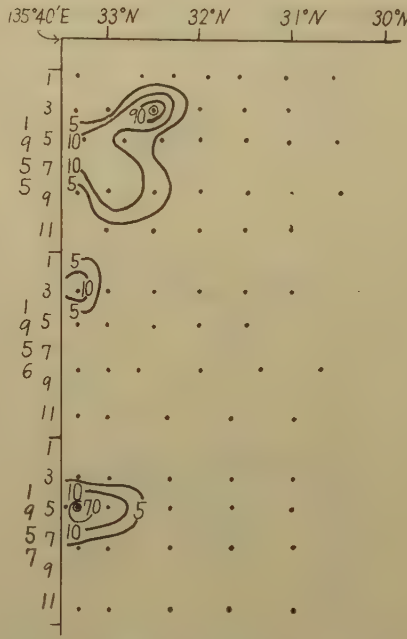

Fig. 7. Individual number of *Sagitta bedoti* per 10 m^3 along Section G south of the cape of Shionomisaki on the Pacific coast of middle Japan during the period from January, 1955 to November, 1957.

the Ridge, even in those from the cold water region. At Stations B and U10 in the cold water region the collections were made respectively at the layers 1040–585 m and 1940–1300 m. And the complete absence of *S. bedoti* in these deep water samples conforms well with that the distribution of this species is confined to the "*bedoti*-water" shallower than 250 m in the surveyed area.

The occurrence of this species along Section G is shown in Fig. 7, which, together with Figures 2 and 3, shows that *S. bedoti* occurs abundantly in the nearshore water in which the water temperature at 50 m layer is below 18°C. This species was found in the samples collected at the offshore station in March, 1955, when the cold water region was very extensive and the stream centre of the Kuroshio was maintained far off the coast.

6) *Sagitta serratodentata pacifica*

The commonest species in the shallow water samples of the Kuroshio region, although fully matured specimens were rather scarce in the present material as shown in Table 1. This species was not found in any samples collected in the Oyashio region and in any deeper water samples from the Kuroshio region, either.

7) *Sagitta ser. atlantica* f. *pseudoserratodentata*

This species was not found in any samples from the Kuroshio region, but was rather common in the far offshore water samples.

8) *Sagitta regularia*

This species occurred in the samples collected from the waters shallower than 760 m in the Kuroshio region west of the Ridge. The occurrence of the species along Section G is shown in Fig. 8 which indicates the significant seasonal fluctuation of increasing in autumn.

9) *Sagitta minima*

Only two individuals were found in the single sample collected at the layer 265–115 m in the Kuroshio region west of the Ridge, but it occurred commonly in samples collected from *ca.* 1000 m to the surface in the far offshore water west of the Ridge and also in samples from the Oyashio region surveyed. This species seems to occur in

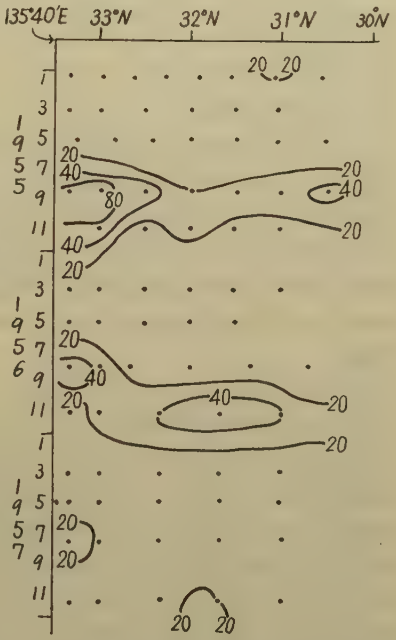

Fig. 8. Individual number of *Sagitta regularis* per 10 m^3 along Section G south of the cape of Shiono-misaki on the Pacific coast of middle Japan during the period from January, 1955 to November, 1957.

the water of rather low water temperatures as compared with other warm-water species.

The occurrence of this species along Section G is shown in Fig. 9. This shows that the occurrence seemed to avoid the winter season, while abundant occurrences were seen when the water temperature at 50 m layer was in the range from 20°C to 24°C.

BIERI (1959) states that *S. minima* to inhabit the regions between water masses or the regions of mixing of the water masses and TOKIOKA (1959) mentions that the abundant occurrence of this species seems to be seen often in or near the region of mixing between the *elegans*-water and the warm water in the North Pacific. The water temperature in the regions of mixing of water masses in the North Pacific agrees with that of the distributional range of this species in the above-mentioned surveyed area, and this seems to show that *S. minima* may occur in the warm water mass when the water temperature is lowered by some causes. The descent of the water temperature in the Kuroshio region is generally caused by the mixing of the coastal water or the cold water mass, besides the seasonal variation of the water temperature itself. And the occurrence of *S. minima* along Section G shown in Fig. 9 seems to reflect the latter phenomenon rather than the former.

10) *Sagitta elegans*

This species occurred abundantly in samples from the Oyashio region, but its proportion was rather small in the deep water sample. It has never been found in either deep water samples or shallow water ones from the Kuroshio region west of the Ridge.

TCHINDONOVA (1955) states that *S. elegans* is an inhabitant of the surface layer, attaining down to 300–400 m in the Kurile-Kamchatka Trench. This is evidently the species characteristic to the Oyashio, but it was quite missing in the deep water sample collected in the adjoining Kuroshio region east of the Ridge because of its subsurface distribution.

11) *Sagitta decipiens*

This is the most important species of the deeper water chaetognaths in the

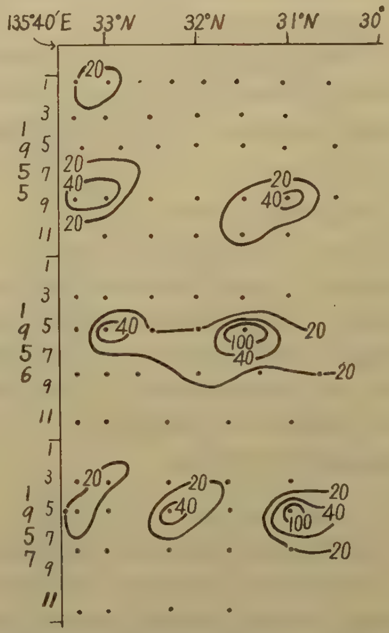

Fig. 9. Individual number of *Sagitta minima* per 10 m^3 along Section G south of the cape of Shiono-misaki on the Pacific coast of middle Japan during the period from January, 1955 to November, 1957.

Kuroshio region and in the far offshore waters beyond the Kuroshio west of the Ridge, though it was not found in the sample collected at the layer deeper than 1000 m. In the eastern Pacific, LEA (1955) reports that *S. decipiens* was caught in 249 m and 366 m hauls made in the open ocean areas off the western coast of Canada. The species seems to be a midwater inhabitant living in the layer of about 100–1000 m in the Pacific as in other oceans.

12) *Sagitta planctonis* & *S. macrocephala*

These species are evidently deep-water forms, but they were very few in the present material. In the sample collected in the layer from 1940 m to 1300 m at St. U10 in the cold water region west of the Ridge in September, 1954, the whole chaetognath fauna was represented by but a single specimen of *S. planctonis* (MATSUDAIRA & FURUHASHI, 1955).

13) *Eukrohnia hamata*

This species occurred frequently in the deep water samples collected in the Kuroshio region, but the collected individuals were very few there. While, this was the most abundant species in the deeper water sample from the Oyashio region and also in the sample from the Kuroshio region east of the Ridge.

TCHINDONOVA (1955) records the abundant occurrence of *E. hamata* together with the occurrence of many specimens of *E. fowleri* in the Kurile-Kamchatka Trench and states that the immature forms are very numerous in the surface layer but the small specimens of *E. hamata* decrease with the depth, being replaced by large ones, and finally younger ones disappear completely but sexually mature forms in the deeper layers. In the present material, all specimens were still immature. It seems that *E. hamata* is distributed in the subsurface water in the Oyashio region, but in the deep layer in the Kuroshio region.

14) *Krohnitta subtilis* & *K. pacifica*

K. subtilis was found in the samples from the 510–115 m layer in the Kuroshio region west of the Ridge and more commonly in the far offshore water samples. *K. pacifica* was found only in the surface water sample in the Kuroshio region west of the Ridge and also in the offshore water samples. *K. subtilis* seemed to be scarce in the surface water of the Kuroshio region but increased in the far offshore water beyond the Kuroshio region west of the Ridge. The vertical distribution of *K. subtilis* in the Kuroshio region west of the Ridge resembles that of *Sagitta lyra* as is seen in Table 1. Both species seem to inhabit in the deeper water and their rather abundant occurrence in samples from the far offshore waters of lower water temperature and higher chlorinity is to be noted. On the other hand, *K. pacifica* is rather common in the surface water of the Kuroshio region.

The occurrence of *Krohnitta* spp. including these two species along Section

G is shown in Fig. 10 which shows that they occurred in the far offshore water more frequently and abundantly than in the nearshore water, exclusive of the single case in May, 1956 when the stream centre of the Kuroshio approached very near the coast.

15) *Pterosagitta draco*

Eleven specimens were found in the surface water samples in the Kuroshio region west of the Ridge and more abundant individuals in the far offshore water samples.

The occurrence of this species along Section G is shown in Fig. 11. This shows that the species occurred more abundantly and frequently in the offshore water than in the inshore water.

Summary and Conclusions

1. Twenty species of chaetognaths were found in the waters off the southern Pacific coast of middle Japan west of the Ridge. Fifteen of these species seem to be tropical or sub-tropical forms and they were found only in

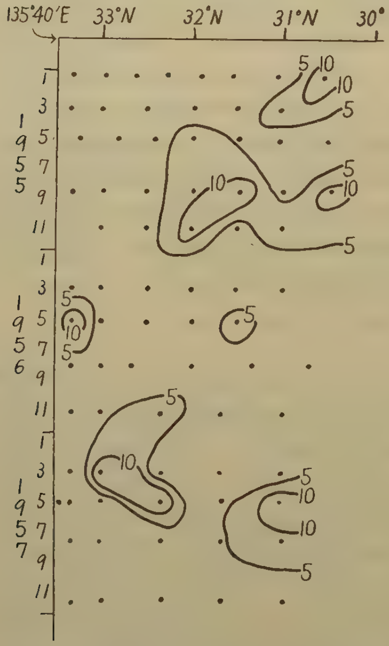

Fig. 10. Individual number of *Krohnitta subtilis*+*K. pacifica* per 10m³ along Section G south of the cape of Shionomisaki on the Pacific coast of middle Japan during the period from January, 1955 to November, 1957.

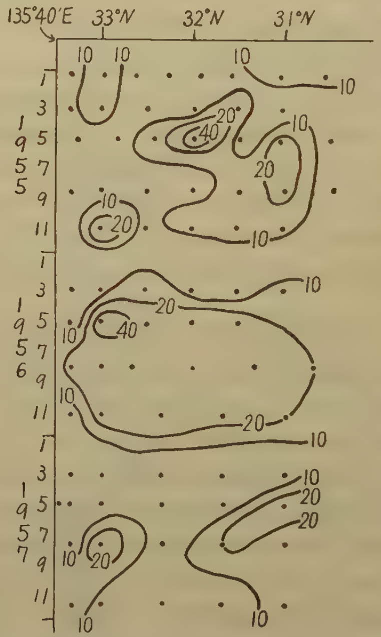

Fig. 11. Individual number of *Pterosagitta draco* per 10 m³ along Section G south of the cape of Shionomisaki on the Pacific coast of middle Japan during the period from January, 1955 to November, 1957.

the upper water samples collected in the layers shallower than 760 m. *Sagitta bedoti* was never found in any deep-water samples, although it was common in the surface water of the cold water region and also in the coastal water. The remaining 4 species are considered to be the abyssal forms; *S. decipiens* was the commonnest species of all the four in the deep waters west of the Ridge.

2. Seven species of chaetognaths were found in the waters east of the Ridge. Three of these seem to be abyssal forms and *Eukrohnia hamata* was the most dominant species in the deep waters east of the Ridge. *S. elegans* characteristic to the Oyashio was found only in the subsurface water samples from the Oyashio region, but never found in either the deeper or upper waters west of the Ridge.

3. The occurrences of chaetognaths along Section G south of the cape of Shionomisaki in the years 1955–'57 were discussed. The seasonal fluctuation was seen clearly in *Sagitta enflata*, *S. regularia* and *S. minima*, the first two were common in the season from summer to autumn, while the last one was found commonly in the season when the water temperatures at 50 m layer was maintained in the range from 20°C to 24°C. The occurrence of *Sagitta hexaptera*, *S. lyra*, *Krohnitta subtilis*, *K. pacifica* and *Pterosagitta draco* seemed to be much affected by the strength of respective water masses found in the surveyed area. Generally they occurred in the far offshore water samples, but also in the inshore water samples when the stream centre of the Kuroshio approached near the coast. *Sagitta bedoti* occurred only in the period when the cold water region became large and its westwards extention reached Section G or beyond it.

4. The difference found in the chaetognath fauna between the deep waters west of the Ridge and that east of the Ridge was not so definitive as in the case of copepods shown in the previous paper of the present author (Furuhashi, 1961). However, the abundant occurrence of *Eukrohnia hamata* might be characteristic to the samples from the deep waters east of the Ridge, while the frequent occurrence of *Sagitta decipiens*, with scarcity of *Eukrohnia hamata*, might be characteristic to the samples from the deep waters west of the Ridge.

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TWO NEW AMPHIPODS OF THE GENUS *EURYSTHEUS* FROM JAPAN

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With 2 Text-figures

No species belonging to the genus *Eurystheus* of the gammaridean amphipods has hitherto been recorded from the coast of Japan. In the neighbouring water of Japan, however, the only one species *E. sexdentata* is known from Liato Peninsula on the Chinese coast (Stephensen, 1944, p. 72, figs. 26, 27). Among the family Photidae the genus *Eurystheus* closely resembles the genera *Megamphopus* and *Podoceropsis*, but differs in having the epistomal spine of upper lip, and usually the multiarticulate accessory flagellum of antenna 1. This genus seems to have rather many species closely resembling one another as enumerated up to fifty-four in number of its valid species in J. L. Barnard's "Index of the gammaridean Amphipoda" (1958, p. 112). K. H. Barnard says in Discovery Reports (1932, p. 224) "There seems to be a never-ending influx of forms in this genus as each fresh expedition brings home its captures. Undoubtedly the simplest way to deal with these forms is to give specific names to each, rather than to assume local variability on the part of one and the same 'species'." In truth, the writer always thinks it wise to creat a distinct species rather than to identify with the known species with hesitation and to result in leading to the error on the point of its geographical distribution, particularly so on the most interesting and frustrating group, until a program on the study of its life history or its multiform is effected.

E. utinomii n. sp. which is described for the first time in the present paper is so far known to occur only in the Seto Inland Sea, and often abundantly appears in the stomach contents of fishes catched there. Another new species *E. japonicus* to be described herein is, though much variable, widely distributed all along the coast of Japan, northerly from Asamushi (Mutsu Bay) southerly to the west coast of Kyûshu, and Nakaumi (Shimane Prefecture).

I wish to express my hearty thanks to the following persons: Dr. T. Hanaoka of the chief of our laboratory for his critical reading of the manuscript; Dr. H. Utinomi of Seto Marine Biological Laboratory, Kyoto University for many valuable

Publ. Seto Mar. Biol. Lab., IX (1), 1961. (Article 3)

advices; particularly to Mr. H. SANDÔ of Tôhoku University, and Mr. T. KIKUCHI of Kyûshu University, for sending the useful materials for this study.

Eurystheus japonicus n. sp.

(Fig. 1)

Male—Pleon segments 4 and 5 armed with two minute medio-dorsal teeth on the hind margin, together with a seta at the base of each lateral tooth. Head, lateral lobes lobate, not pointed apically. Side plate 2 the largest and the deepest. Pleon segment 3, lower hind corner with an acute tooth, margin above bulging, then nearly straight. Eyes long oval, reniform and dark. Accessory flagellum of antenna 1 five-seven jointed. Upper lip with epistome produced acutely and right-angularly in front. Gnathopod 1, article 5 slightly longer than article 6; palm ill-defined; finger denticulate. Gnathopod 2 larger and powerful; articles 2 and 5 robust and subequal; the anterodistal corners of article 2 lobate; article 6 nearly equal to or slightly longer than article 5; palm oblique with three denticles or tubercles of which the middle one in specimens from Seto Inland Sea is the largest and projecting across the finger, whereas the appearence of these denticles in Asamushi specimens, rather resemble those of SARS' figures of *E. maculatus* (1895, pl. 198); hind margin of article 6 sometimes shorter than palm, sometimes longer, and nearly parallel with its anterior margin. Peraeopods 3–5 with articles 2 and 4 much variable in shape and the hind margin slightly serrated; peraeopod 4 longer than or subequal to peraeopod 5; peraeopod 3, article 2 well expanded and broadened distally, article 4 more or less widened; peraeopod 4, article 2 well expanded or rather narrow, and its hind margin convex or slightly concave, article 4 less widened; peraeopod 5, article 2 more or less narrowing distally, article 4 normal. The other points typical without any characteristics.

Female—Differing from the male only in peraeon segment 2 and its coxal plate, gnathopod 2, and peraeopods 3–4. The breadth of peraeon segment 2 and the depth of its coxal plate normal. Gnathopod 2 not powerful and not variable; article 2 rather slender; article 5 much shorter than article 6 of which palm with two denticles, widely concave between the two, and bearing a rather strong spine near the defined denticle. Peraeopods 3–5 not variable; article 2 of peraeopod 3 moderately broadened, and those of peraeopods 4–5 narrowing distally; the shapes of article 2 of peraeopods 3–5 in Asamushi specimens are, however, somewhat different from those of specimens from Seto Inland Sea in the longer and more slender shape to their width.

Type locality—St. 1, Hosonosu, Hiroshima Pref., Seto Inland Sea, Dec. 12, 1956. Holotype, male 8 mm (figured), No. 2055; Allotype, ovig. female 6 mm (figured), No. 2089, and 2 paratypes, all preserved now in my hand.

Occurrence—Seto Inland Sea: Hosonosu, 11 specimens; Mihara Bay, 10 spec.

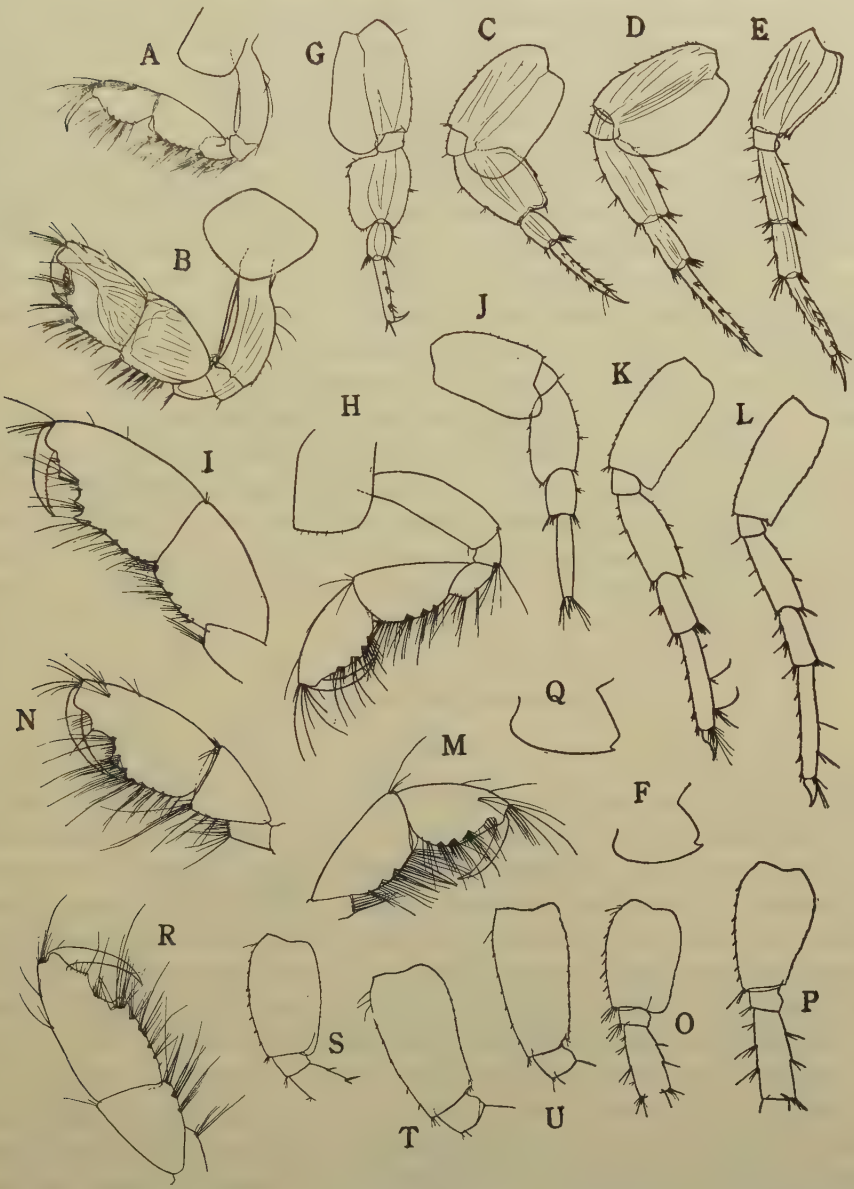

Fig. 1. *Eurystheus japonicus* n. sp., Seto Inland Sea: male, 8 mm., A and B–gnathopods 1 and 2, C to E–peraeopods 3–5, F–epimeral plate 3; male 5.8 mm., G–peraeopod 3; ovig. female, 6 mm., M and N–gnathopods 1 and 2, O and P–peraeopods 3 and 4, Q–epimeral plate 3: Mutsu Bay: male, 5 mm., H and I–gnathopods 1 and 2, J–to L–peraeopods 3–5; ovig. female, 4.5 mm., R–gnathopod 2, S to U–peraeopods 3–5. Peraeopods 3–5 the same proportion of enlargement in each specimen.

Asamushi, Mutsu Bay, northern Japan, 74 spec., coll. Mr. H. SANDÔ. Tomioka Bay, the west of Kyûshu, 1 spec., and Nakaumi, Shimane Pref., 6 spec. from the stomachs of fishes, both coll. Mr. T. KIKUCHI.

Remarks—This species is much closely related to the type *E. maculatus* and *E. thompsoni*, particularly in the structure of male gnathopod 2, but differs from the former in the color of eyes, the shape of epimeral plate 3, having two small medio-dorsal teeth also on pleon segment 5, and the shape of article 2 of peraeopods 3-5; from the latter (WALKER 1898, p. 283, pl. 16, figs. 3-6; SHOEMAKER 1942, p. 28, fig. 10, as the name of *tenuicornis* and its var. *lobata*), in the deepest side plate 2, rather different shape of epimeral plate 3, and much broadened articles 2 and 4 of male peraeopods 3-4. Both *maculatus* and *thompsoni* are not likely to be described at all on such a remarkable difference in sexes on peraeopods 3-5. The writer, however, remembers a certain coincidence with only a male specimen reported by CHILTON under the name of *maculatus* from the Australian Sea (1921, p. 80, fig. 12) in which articles 2 and 4 of peraeopod 5 (3 ?) are somewhat broadened in shape. These all curious specimens at hand, might be said to be an intermediate form between *maculatus* and *thompsoni*. Asamushi specimens are the same form as the specimens from both Tomioka Bay and Nakaumi, and seem to be a variety of the specimens from the type locality and herein described and figured together.

Eurystheus utinomii n. sp.

(Fig. 2)

Male—Medio-dorsal teeth of pleon segments 4 and 5, the largest and the deepest side plate 2, eyes, and antennae, are all as in the preceding species. Head, lateral lobes lobate, but minutely pointed at apex. Lower hind corner of pleon segment 3 with a minute tooth, bulging above, its hind margin convex. The other oral parts are proper for this genus and without any characteristics. Side plate 1 with lower hind margin dentate. All legs rather slender than those of the preceding species. Gnathopod 1, article 5 longer than article 6 of which palm ill-defined. Gnathopod 2 strongly developed and the right and left legs usually crossing each other under the body; article 2 powerful; articles 5 and 6 much elongate, club-shaped, thickly grown up, and subequal in length; palm indistinct, being in a straight line with the hind margin, and having no tubercles; posterior margin of articles 5 and 6 heavily bristled; article 7 rather stout and short, and having many blunt teeth along the inner margin. Peraeopods 3-5 successively longer; peraeopods 4 and 5 with article 2 well expanded, particularly that of peraeopod 5 much expanded, triangular or subquadrate in shape, its anterior margin bearing two large teeth, near the points attached to side plate with a triangular tooth, and the hind margin roughly dentate Uropods and telson normal as in the type.

Female Distinguished from the male by the following points: Gnathopod 2 rather slender; palm of article 6 short, but distinctly visible. Peraeopods 3–5, article 2 not much expanded; article 4 normal in width.

Type locality—St. 6, 10 m in depth, below low tide marks of Mihara Bay. June 15, 1956. Holotype, male 7.5 mm (figured), No. 2029; Allotype, oviger. female 6.5 mm (figured), No. 2257, and 19 paratypes, all preserved now in my hand.

Occurrence—Seto Inland Sea: Mihara Bay, St. 5 (4 spec.), 6 (332), 7 (412), 8 (954), between Feb. 1956 and Aug. 1956; many specimens from the stomachs of fishes.

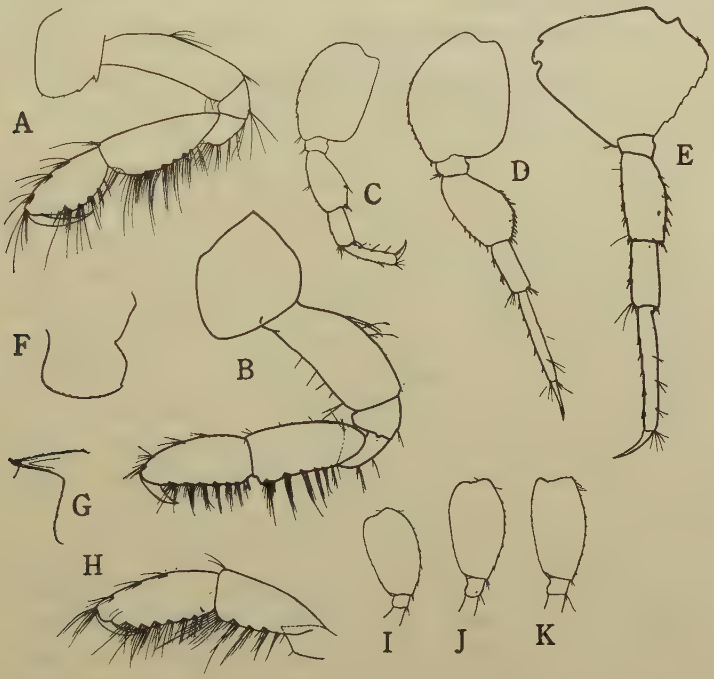

Fig. 2. *Eurystheus utinomii* n. sp., male, 7.5 mm., A and B–gnathopods 1 and 2, C to E–peraeopods 3–5, F–epimeral plate 3, G–epistomal spine; ovig. female, 6.5 mm., H–gnathopod 2, I to K–peraeopods 3–5. Peraeopods 3–5 the same proportion of enlargement in each specimen.

Remarks—This species can be easily recognized by the unique characteristics of male gnathopod 2 and the shape of article 2 of male peraeopod 5. The writer knows of no other species in this genus having such a remarkable one, except *E. longicarpus* Reid (1951, p. 259, fig. 50) which has a rather similar structure of male gnathopod 2. Differing from the latter, in the shape of eye, the deepest side plate 2, rather different shape of epimeral plate 3, much more elongated, club-shaped articles 5 and 6 of male gnathopod 2, its palm having no prominences, and the shape of article 2 of peraeopod 5. It gives me a great pleasure to name this characteristic new species after Dr. H. Utinomi.

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ON THE IDENTIFICATION AND THE AFFINITY OF *TAMANOVALVA LIMAX*, A BIVALVED SACOGLOSSAN MOLLUSC IN JAPAN[1]

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With Plates I-IV and 3 Text-figures

Just after the publication of the preliminary note on a bivalved sacoglossan, *Tamanovalva limax* Kawaguti & Baba, 1959, I was advised by Dr. Tokubei Kuroda of the Kyoto University to identify *Tamanovalva* again with the questioned bivalve *Edenttellina.* He was kind enough to take pains in obtaining some necessary literature (Gatliff & Gabriel, 1911; Hedley, 1912, 1920; Cotton & Godfrey, 1938, etc.) from his private library and from the Kyoto University libraries in the interest of my treatise. Reference to Verco's (1911, 1916) was made possible by the courtesy of Mr. Robert Burn in Australia. During this time, I was called attention by Drs. L. R. Cox and W. J. Rees (1960) of the British Museum to the similarity of *Tamanovalva* with *Edenttellina* and with the Parisian fossil bivalve *Ludovicia* (see also Hedley, 1912). Also I was asked by Dr. Myra Keen (1960a, 1960b) of the Stanford University to go further to identify *Tamanovalva* with *Berthelinia,* known as an embryonic gastropod shell from the Paris Basin. There arose thus a *Tamanovalva-Edenttellina-Ludovicia-Berthelinia* connection which awaited thorough revision[2]. I am greatly indebted to Drs. L. R. Cox and W. J. Rees who have kindly sent me the copied text of the "catalogue" by Cossmann, 1888. In referring to Cossmann, I owe much also to Dr. Myra Keen.

Thanks to Dr. Tadashige Habe of the Amakusa Marine Biological Laboratory,

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[1] Contributions from the Tamano Marine Laboratory, No. 82.

[2] Before the completion of the present paper, an essay by Mr. R. Burn (1960b) has been sent me announcing the synonymy of *Tamanovalva* with *Edenttellina,* and the creation of a new genus *Midorigai* from Victoria (see also Burn, 1960a). Previous to this, I was told by a letter from Dr. Myra Keen of her success in collecting a living bivalved sacoglossan from the Gulf of California in August, 1960. Also it is said that a fossil species of the sacoglossan bivalves was obtained from South Australia by Dr. N. H. Ludbrook and Mr. T. M. Steel in 1960 (by letters from Dr. Ludbrook and Mr. Burn).

Publ. Seto Mar. Biol. Lab., IX (1), 1961. (Article 4)

I was able to make a bibliographical review of the primitive sacoglossan genus *Arthessa*.

Specimens of *Tamanovalva* employed in the present study have been obtained mainly from the Inland Sea of Seto, Japan (Tamano, Aug. 1959; Aug. 1960; Mar. 1961; Mukaishima, Mar. and June 1960); partly from the Toyama Bay, Japan Sea (Abugashima, Aug. 1959; Aug. 1960). Willing cooperations for collecting were afforded by Dr. Siro KAWAGUTI (Tamano Marine Laboratory), Dr. Akihiko INABA (Mukaishima Marine Biological Station) and Mr. Takeo ABE (Takaoka Senior High School, Toyama Pref.).

For the aim of the comparative anatomy, the following genera and species have especially been taken into consideration¹⁾:

1. *Edenttellina typica* GATLIFF & GABRIEL, 1911.
   Flinders, Victoria, Mar. 1960, 1 sp. (shell-length 2.5 mm), presented by Mr. BURN, designated at first as *Midorigai australis* "paratype", but later suggested to be the above species.

2. *Oxynoe viridis* (PEASE, 1861).
   Misaki, Sagami Bay, Aug. 1951, 3 sps. (total length of animal 25 mm), presented by His Majesty's Biological Laboratory; Abugashima, Toyama Bay, Aug. 1954, 1 sp. (total length 18 mm), presented by Mr. ABE. See BABA, 1952a, 1955.

3. *Lobiger sagamiensis* BABA, 1952.
   Misaki, Sagami Bay, Aug. 1951, 3 sps. (total length 10 mm), presented by His Majesty's Biological Laboratory. See BABA, 1952b, 1955.

The presentation of this paper in the printed form is due to Dr. Huzio UTINOMI of the Seto Marine Biological Laboratory.

I wish to express my cordial thanks to all who have helped me in various ways.

I. Review of the Previous Records

The following is a list of genera and species considered to be in close connection with each other:

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1) A comparative study has also been made on the species and subspecies listed below, the actual specimens of which being offered me for exchange.

1. *Berthelinia typica* BURN, 1960 (non *Edenttellina typica* GATLIFF & GABRIEL, 1911).
   Torquay, Victoria, Mar. 1960, 1 sp. (shell-length 4 mm), collected by Mr. BURN. See BURN, 1960a, 1960b.
2. *Midorigai australis* BURN, 1960.
   Torquay, Victoria, Nov. 1960, 8 sps. (shell-length 1–4.6 mm), collected by Mr. BURN. See BURN, 1960a, 1960b.
3. *Berthelinia chloris* (DALL, 1918), subspecies.
   Espiritu Santo I., Gulf of California, Dec. 1960, 2 sps. (shell-length 4.5–7 mm), collected by Dr. KEEN. See KEEN, 1960b.

1. *Berthelinia* Crosse, 1875.
   - † *B. elegans* Crosse, 1875. Paris Basin Eocene (Courtagnon). A single left valve (Pl. I, figs. 14A–14B).
   - † *B. elegans* (?) by Crosse & Fischer, 1887. Paris Basin Eocene (Le Ruel, etc.). Left and right valves (Pl. I, figs. 15A–15B).
   - † *B. elegans* (?) by Cossmann, 1888. Paris Basin Eocene (Château-Rouge). Right valve (Pl. I, figs. 16A–16B).
   - † *B. elegans* (?), var. *elata* Cossmann, 1888. Paris Basin Eocene (Le Ruel). Left and right valves (Pl. I, figs. 17A–17B).

The shell of the genotype is 0.5 mm long, and, as a developmental stage, it corresponds roughly to the youngest adult form of *Tamanovalva* (see Kawaguti, 1959, p. 610, figs. 7a–7c; see also Text-fig. 2, B–D). The coil of the protoconch in the genotype is said to consist of 2 whorls; the matured shell, which must be differentiated more, was not traced originally.

2. *Ludovicia* Cossmann, 1888.
   - † *L. squamula* Cossmann, 1888. Paris Basin Eocene (Parnes). Left and right valves (Pl. I, figs. 18A–18B).

The shell is exceedingly large (twice as large as the biggest shell of *Tamanovalva*); moreover, it may be added that this is "very inequilateral, highly dilated in front, obtuse behind, and provided with a small protoconch at the latter one-fourth of the shell-length".

3. (?) *Anomalomya* Cossmann, 1888.
   - † *A. corrugata* Cossmann, 1888. Paris Basin Eocene (Le Fayel). A single right valve (Pl. I, figs. 19A–19B). Protoconch unknown.

4. *Edenttellina* Gatliff & Gabriel, 1911[1].
   - *E. typica* Gatliff & Gabriel, 1911. Victoria (Port Sea, etc.). Left and right valves (Pl. I, figs. 20A–20B).
   - *E. typica* (?) by Verco, 1916. South Australia (Guichen Bay), in shell sand. Left and right valves.
   - *E. typica* (?) by Hedley, 1920.
   - *E. typica* (?) by Cotton & Godfrey, 1938.
   - *E. typica* (?) by Burn, 1960a. Victoria (Torquay). Living animals on *Caulerpa*.
   - *Berthelinia typica* (?) by Burn, 1960b.
   - *E. corallensis* Hedley, 1920. North Queensland, in 5–10 fms. coral mud. Left and right valves (Pl. I, figs. 21A–21B).

Originally the shell of the genotype is shown thus (summarized): "Shell

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[1] See the comment by Hedley, 1912.

3 mm long, flattened, broadly ovate, very inequilateral, anterior side somewhat swollen; slightly convex, yellow; incurved protoconch of a rounded form, coiled, overlapping the right valve; hinge-line without teeth". The annexed figures show that the shell is abruptly rounded behind, and the protoconch marks its position at the latter one-fourth of the shell-length (cf. *Ludovicia*).

E. typica VERCO (and HEDLEY) differs from the genotype as follows: (1) the shell is markedly narrowed posteriorly, and (2) the protoconch, seemingly large in size, coiled in 2 whorls, and standing erect, is found at the latter one-third of the shell-length. *E. corallensis* HEDLEY is separated from *typica* VERCO (and HEDLEY) by having the shell "more solid, more compressed, and more pointed posteriorly" than in the latter species. Unfortunately the protoconch in *corallensis* was not shown in detail. *E. typica* COTTON & GODFREY is the union of two different species, the genotype and *typica* VERCO (and HEDLEY). *E. typica* BURN comes to be re-identified.

5. *Tamanovalva* KAWAGUTI & BABA, 1959.
   T. limax KAWAGUTI & BABA, 1959. Japan.

6. *Midorigai* BURN, 1960.
   M. australis BURN, 1960, "holotype". Victoria (Torquay). Living animals on *Caulerpa*.

II. The Comparative Anatomy of *Tamanovalva limax*

The Shell: In *Tamanovalva* the shell is bivalved, the bipartition of a shell taking place during metamorphosis (KAWAGUTI, 1959)[1]. The two valves when completed are almost equal in size, shape and convexity; they are extremely thin and fragile (Text-fig. 1, B; Pl. I, figs. 1A–1B, 2A–2B). The periostracum is colourless, the pearl layer is shiny, and the intermediate calcareous layer assumes a faint tinge of green; the general colour effect of the hyaline shell is pale yellowish green or yellowish white in different specimens. Sometimes there are traces of radiating, obscure bands of yellow on the shell. The maximum size of the full-grown shell is about 8 mm long, 5.5 mm high and 2.5 mm broad. The helicoid protoconch at the apex of the left valve is porcelain white with 1½ sinistral turns (Pl. I, figs. 3A–3B; Pl. II, figs. 2–3); it is always small, inclined fairly to approach a horizontal plane in the adult shell, and extended over the right valve (Pl. I, fig. 3C; Pl. II, fig. 6). The umbos of the two valves are more or less swollen, but not so highly elevated like in *Midorigai* (Text-fig. 3; Pl. I,

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[1] The youngest bivalve is asymmetrical, the right valve being smaller and less inflated than the left one (Text-fig. 2, B–D). Soon the two valves become almost equal in dimension, with their umbos accentuated (Text-fig. 2, E–I). At first the protoconch stands erect to the left valve, but later it tends to be gradually inclined horizontally. A greenish adult shell may be seen when it attains the length of about 2.5–3 mm. In this case the swelling of the umbos and the inclination tendency of the protoconch are subjected to a certain extent to an individual variation.

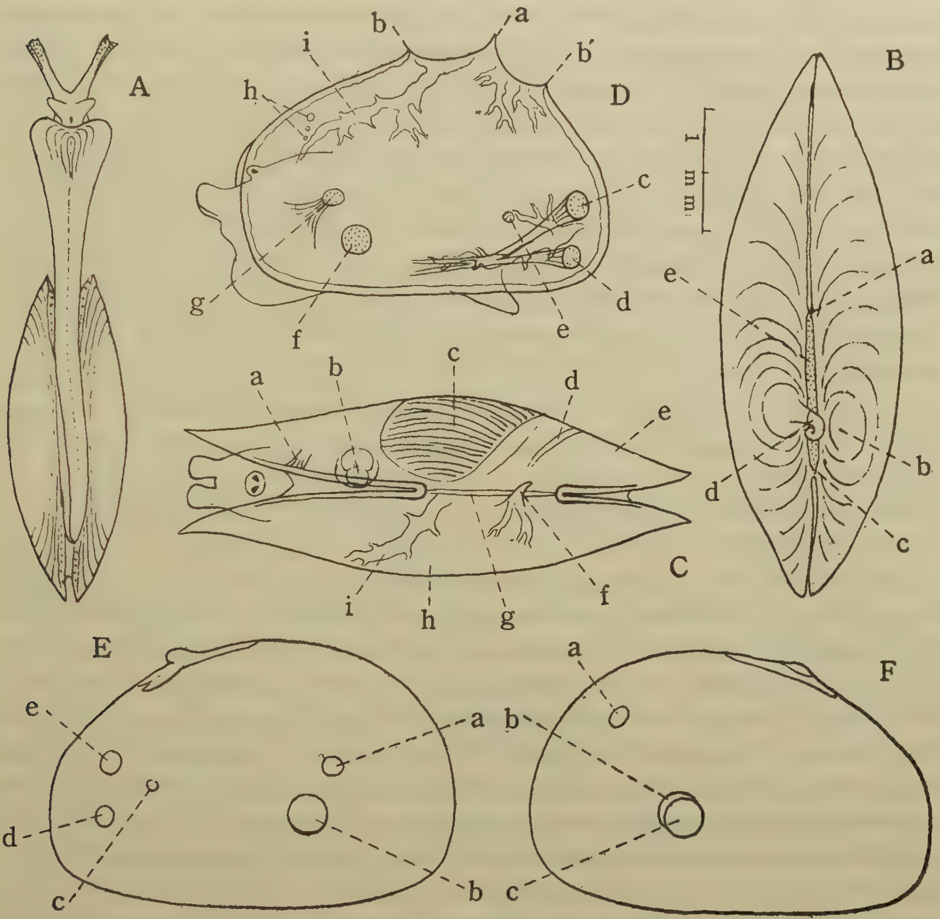

Fig. 1. *Tamanovalva limax* (Tamano, Inland Sea of Seto, Aug. 20, 1959). A. Ventral view of an extended animal. B. Dorsal view of a paired shell (shell-length 4.3 mm). a. anterior articulation of the hinge, b. umbo of the right valve, c. posterior articulation of the hinge, d. protoconch of the left valve, e. ligament. C. Naked animal in a contracted state, dorsal view. a. right head retractor, b. heart, c. gill, d. "ciliated ridge", e. right mantle, f. horn of the visceral sac (h), g. median dorsal line of the visceral sac having a hinge-groove, i. branching sinus. D. Naked animal in a contracted state, left side view. a. horn of the visceral sac, b–b′. median dorsal line of the visceral sac, c. right tail retractor, d. left tail retractor, e. transverse visceral muscle, f. adductor muscle, g. left foot retractor, h. branchings of the right head retractor, i. branching sinus. E. Left valve from inside. a. scar of the left foot retractor, b. scar of the adductor muscle, c. scar of the transverse visceral muscle, d. scar of the left tail retractor, e. scar of the right tail retractor. F. Right valve from inside. a. scar of the right head retractor, b. scar of the right foot retractor, c. scar of the adductor muscle.

figs. 11–12). Each of the shell valves develops an elongate hinge-plate below the umbo; the hinge-plate itself is slightly sloping from the upper margin to the lower border, plain on the surface (no teeth here, see Gatliff & Gabriel, 1911; Kawaguti & Baba, 1959), and serves for the attachment of an ashy yellow ligament. The two valves are slightly articulated at the front and rear ends of the hinge as follows (Pl. I, figs. 4A–4B; Pl. II, figs. 4A–4B, 6A–6B, 7A–7B; see also Verco, 1916; Hedley, 1920): (1) A weak anterior cardinal to the right valve; a corresponding shallow socket to the left valve. (2) A massive posterior cardinal to the right valve; a corresponding deep socket to the left valve. (3) An elongate posterior cardinal to the left valve; a corresponding shallow socket to the right valve. The left and right valves are combined also by a thin periostracum which bridges over the ligament (Pl. II, fig. 8).

In shells, *Edenttellina* and *Tamanovalva* differ from each other as below (for *Edenttellina*, see Pl. I, figs. 9A–9B, 20A–20B; Pl. II, figs. 5A–5B):

Edenttellina typica	*Tamanovalva limax*
1. Shell very inequilateral, abruptly rounded behind.	1. Less inequilateral; gradually narrowed and rounded behind.
2. Protoconch at the latter one-fourth of the shell-length.	2. At the latter one-third of the shell-length.

Soft Part of Body: In the general organization of the soft part of the body, *Tamanovalva* is not differentiated greatly from *Edenttellina*. The head is bilaterally symmetrical (Pl. II, fig. 1); it has auriculate rhinophores and lobiform oral tentacles. It is notable that the paired eyes are close together in *Tamanovalva* (Pl. III, fig. 2), the eye-region forming a small projection on the head in the median line (cf. *Oxynoe* and *Lobiger* in Pl. IV, figs. 6, 7). Structurally these eyes are as usual in the Opisthobranchia (vesicular eyes with a large spherical lens and abundant black pigment within each of them; see also Eales, 1921). The male orifice opens on the right side of the neck, but not below the right rhinophore (Pl. III, Fig. 1). The female orifice is found far back on the right wall of the visceral sac. The widely separated situation of the male and female openings represents one of the primitive features existing in the order Sacoglossa (cf. *Oxynoe* and *Lobiger* in Pl. IV, figs. 6, 7). The more striking is the presence in *Tamanovalva* of the external genital groove on the right of the head and neck (Pl. III, fig. 1). This groove commences from a point moderately in front of the female orifice, and runs below the male orifice as far as to the outer base of the right oral tentacle. In *Tamanovalva*, the genital groove, ciliated, appears to serve as an open canal for the passage of the eggs (hence it is better called the external oviducal groove 1)). It is problematical whether the external oviducal groove in *Tamanovalva* may be identified with the external seminal one in many

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1) Observations on the deposition by way of the external oviducal groove in *Tamanovalva* have been given by Dr. S. Kawaguti and Mr. T. Yamasu (1960b).

of the lower Opisthobranchia (e. g. *Bulla, Cylindrobulla, Philine, Aplysia, Dolabella,* etc.). The external oviducal groove in *Tamanovalva* is not existing in *Oxynoe* and *Lobiger* (cf. Pl. IV, figs. 6, 7). The head and neck is fastened to the upper lateral wall of the right mantle by the right head retractor (Pl. III, fig. 1).

The Visceral Sac and the Mantle: The visceral sac, contained in the hollow of the left valve, is greatly compressed from side to side, and assumes the superficial appearance of a bivalve (Text-fig. 1, C); materially the visceral sac of *Tamanovalva* is asymmetrical in organization (see Pl. III, figs. 3, 4; Pl. IV, figs. 1, 3, 4). The mantle covering the visceral sac is divided into two unequal lobes; the two hung down to the level of the foot, on opposite sides of the latter. The entire margin of the mantle is double (cleft in two lappets), and it appears to produce shell substance for the growth of each of the valves. Along the median dorsal line of the visceral sac, the mantle forms a shallow depression which is designated here as a hinge-groove (Text-fig. 1, C; Pl. II, fig. 8). Beyond the length of the hinge-groove, before and behind, the bipartition of the mantle becomes gradually marked, and finally there is a mantle lobe formed on each side of the visceral mass (Text-fig. 1, C, D; Pl. III, fig. 1). A deep mantle cavity is present between the visceral mass and the right half of the mantle (Pl. III, figs. 3, 4; Pl. IV, figs. 3, 4). The gill develops as a belt of thin, longitudinal folds on the under side of the right mantle (Text-fig. 1, C; Pl. III, fig. 1; see also Pl. III, figs. 3, 4; Pl. IV, figs. 1, 3, 4). A current of fine cilia occurs on the surface of these folds. The gill in *Tamanovalva* is evidently homologous with that in *Oxynoe* and *Lobiger* (Pl. IV, figs. 6, 7; see also *Oxynoe viridis* of ELIOT, 1906; *Lobiger serradifalci*=*L. philipii* of PELSENEER, 1894; *L. souverbiei* of MARCUS, 1957). An osphradium is found close to the gill (Pl. III, fig. 1; see also Pl. III, figs. 3, 4; Pl. IV, fig. 3). It is a simple cutaneous organ covered with long cilia. As in *Oxynoe* and *Lobiger* (see PELSENEER, 1894; ELIOT, 1906; MARCUS, 1957), the kidney of *Tamanovalva* is contained in the interior of the right mantle (Pl. III, figs. 3, 4; Pl. IV, figs. 1, 3, 4). The renal cells are cubic as usual. The nephroproct opens to the mantle cavity at the latter one-third of the right mantle (Pl. III, fig. 1; Pl. IV, fig. 5). Antero-dorsally the kidney is communicated with the pericardium by a reno-pericardial canal (Pl. IV, figs. 1, 2). The hypobranchial gland is behind the gill and within the right mantle in *Oxynoe* and *Lobiger* (Pl. IV, figs. 6, 7; see also MARCUS, 1957). In *Tamanovalva*, the same gland as this occurs diffusely on the surface of the visceral sac, posterior to the anus (Pl. III, fig. 1; see also Pl. III, figs. 3, 4). Each gland cell is small and flask-shaped, and produces a stream of viscid, milky fluid which takes eosin in preparations. In *Tamanovalva* there is a marked "ciliated ridge" running up on the rear wall of the visceral sac (Pl. III, fig. 1; see also Pl. III, figs. 3, 4); it passes down on the inner wall of the right mantle. A ciliary current is especially strong on the ridge. The "ciliated ridge" similar to that of *Tamanovalva* appears also in *Oxynoe*

(Pl. IV, fig. 6), *Cylindrobulla* (see Ev. Marcus & Er. Marcus, 1956) and others, but not in *Lobiger*. One of the most striking features in the organization of *Tamanovalva* is the possession of a smooth, horizontal, adductor muscle running across the former one-third of the visceral sac; the adductor muscle serves to

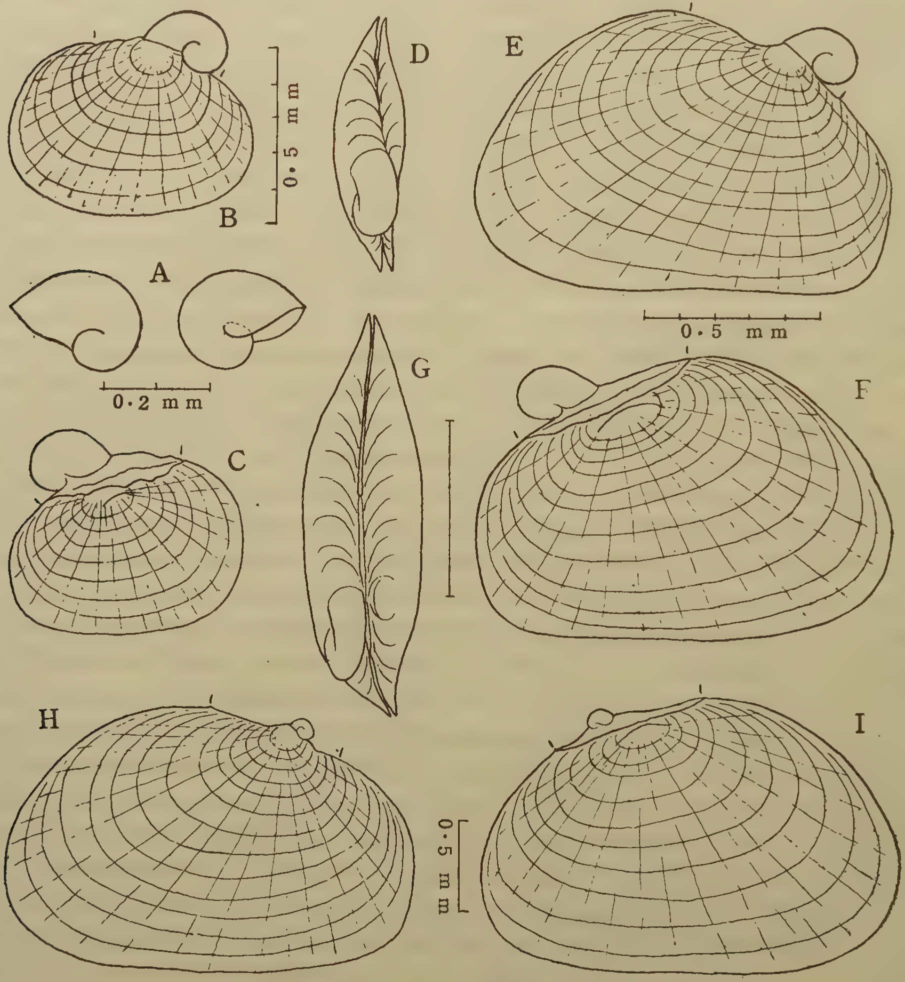

Fig. 2. *Tamanovalva limax* (Tamano, Inland Sea of Seto, Mar. 2, 1961). Young shells in successive stages of development. A. A veliger's shell from left and right sides. B–D. A youngest bivalve (shell-length 0.7 mm) nearly in the adult form, from left, right and dorsal sides. At this stage the shell is very transparent and colourless; the soft part of the body is equally colourless excepting the brownish liver which shines through. E–G. A slightly advanced bivalve (shell-length 1.2 mm). The colour is as before. H–I. A more advanced bivalve (shell-length 2.2 mm). The shell is transparent and colourless as yet, but the soft part now assumes a tinge of grass-green.

unite the left valve with its partner (Text-fig. 1, D, E, F; Pl. III, figs. 1, 3, 4; Pl. IV, fig. 1; see also KAWAGUTI & YAMASU, 1960a). A strong, oblique, adductor muscle is shown in the body of *Cylindrobulla* (see Ev. MARCUS & Er. MARCUS, 1956).

Foot: The foot is narrow with a flat sole (Text-fig. 1, A); this latter may easily be folded longitudinally along the median line. The flask-shaped, multicellular pedal glands are thickly distributed everywhere below the ciliated epithelium of the sole. The general pedal glands are basophile, but those aggregated round the oral invagination are each specialized in having an eosinophile secretion. The tail is very short. The musculature of the foot and tail¹⁾ consists of (1) the left foot retractor, (2) the right foot retractor, (3) the left tail retractor, and (4) the right tail retractor. The left and the right ones are not strictly paired in arrangement (Text-fig. 1, D, E, F; see also Pl. III, figs. 1, 3, 4; Pl. IV, fig. 1).

The Nervous System: The chief ganglia composing the nervous system in *Tamanovalva* are identified as follows²⁾ (Pl. II, figs. 11, 12, 13; Pl. III, figs. 3, 4): Paired cerebro-pleural, paired pedal, paired buccal, paired parietal (infra-intestinal on the left, supra-intestinal on the right), unpaired visceral (=abdominal), unpaired osphradial, and unpaired genital ganglia. Of these the first two are centralized, and constitute a nerve ring surrounding the oesophagus. The two cerebro-pleural ganglia, dorsal to the oesophagus, are united by a commissure, and linked with the pedal granglia by a double connectives. There are no rhinophorial ganglia. The pedal ganglia on the ventral side of the oesophagus are almost completely fused together, with a fairly long parapedal commissure between the two. A statocyst is closely fixed upon each of the pedal ganglia. It contains a statolith within the cyst ciliated internally. The buccal ganglia remain as usual. The paired visceral nerve cords (=the left and the right pleurovisceral connectives) are long, and not completely untwisted (Pl. II, figs. 11, 12). The infra-intestinal ganglion is always smaller in size than the supra-intestinal. The osphradial ganglion is closely applied to the osphradium of the right mantle (Pl. II, fig. 11; Pl. III, figs. 3, 4; Pl. IV, fig. 3). The visceral ganglion occurs within the visceral sac (Pl. II, figs. 11, 12; Pl. III, fig. 4; Pl. IV, fig. 3). A small genital ganglion appears in the length of the genital nerve from the visceral ganglion. The long visceral loop thus shown above is very important in the Sacoglossa, and it demonstrates an ancestral affinity of *Tamanovalva* with those ranked lower in the Opisthobranchia (e.g. *Actaeon*, *Scaphander*, *Bulla*, etc.; see GUIART, 1901; PELSENEER, 1894). A somewhat streptoneurous nervous system is

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1) The arrangement of the various muscles in *Tamanovalva* has been shown by Dr. S. KAWAGUTI and Mr. T. YAMASU (1960c).

2) See the basic pattern and modifications of the opisthobranch nervous system by GUIART, 1901; RUSSELL, 1929.

recorded also from the primitive sacoglossan *Arthessa* (see EVANS, 1950), but the account given of this is only brief. In the genera *Oxynoe*, *Lobiger* and *Elysia*, the chief ganglia are greatly centralized, and there is a considerable shortening of the visceral loop (for *Lobiger*, see PELSENEER, 1894; MARCUS, 1957; for *Elysia*, see RUSSELL, 1929). In a fresh specimen of *Tamanovalva*, the nerves are colourless, and the ganglia are yellow.

Digestive System: The digestive system in *Tamanovalva* is typically of the sacoglossans (Pl. II, figs. 11, 12, 13; Pl. III, fig. 3; Pl. IV, figs. 1, 3, 4), and most closely comparable with that in *Oxynoe* and *Lobiger* (for *Lobiger*, see PELSENEER, 1894; MARCUS, 1957). The pharyngeal bulb is pear-shaped, yellowish green in life, and fastened to the latero-ventral wall of the head by a pair of retractor muscles. The radulae in *Tamanovalva*[1], *Edenttellina*, *Oxynoe* and *Lobiger* are almost alike in general configuration, differing in some points as follows (for *Tamanovalva*, see Pl. II, fig. 9; see also KAWAGUTI & BABA, 1959; for *Edenttellina*, Pl. I, fig. 10; Pl. II, fig. 10; for *Oxynoe*, refer to BABA, 1952a, 1955; for *Lobiger*, BABA, 1952b, 1955).

Tamanovalva limax	*Edenttellina typica*	*Oxynoe viridis*	*Lobiger sagamiensis*
1. Ascending teeth 5–7, descending teeth 30–35.	1. Ascending 6, descending 23.	1. Ascending 10, descending 22.	1. Ascending 4, descending 7, 12–13 in a heap.
2. All teeth denticulated on both edges.	2. All non-denticulated, smooth.	2. All denticulated.	2. Ascending teeth smooth, descending teeth denticulated.
3. All teeth simple at tip.	3. Bifid at tip.	3. Simple at tip.	3. Simple at tip.

The genera *Tamanovalva*, *Oxynoe* and *Lobiger* are differentiated from each other as below:

Tamanovalva	*Oxynoe*	*Lobiger*
1. Pharyngeal crops paired, each elongated sac-like, internal cavity simple.	1. A single circular crop.	1. A single crop on the left, exceedingly elongated, rhombic in cross section, internal cavity double.
2. Salivary glands paired, each exceedingly elongated, tubular, opening by a fine duct.	2. Paired, each a villous cluster of tubules opening by a stout common duct.	2. Paired, each a grape-like cluster of tubules opening by a small common duct.
3. Oesophageal diverticulum single, smooth on surface.	3. Single, warty on surface.	3. Single, smooth or warty on surface.

In *Tamanovalva*, the pharyngeal crops take the form of an elongated sac with a thick muscular wall; internally they have rugose folds covered with cilia (Pl.

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[1] Actually the radula consists of a continuous row of teeth, but it is often seen split into two parts, the ascending and the descending (see Pl. I, fig. 6; cf. BURN, 1960b). The total number of the teeth within a single row may vary considerably in different specimens.

II, figs. 11, 12, 13, 14; Pl. IV, fig. 1). The whole body of the crops is slightly yellowish green. The salivary glands are colourless, hyaline and delicate (Pl. II, figs. 11, 12). They consist of an exceedingly elongated tubular gland which is faintly rugose on the surface, and a very fine duct. The wall of the glandular portion is made up of secretory cells and interstitial ones; the lumen of the tube is finely ciliated (Pl. II, fig. 15). The two salivary glands cling to the under side of the oesophageal diverticulum by their distal end. The oesophageal diverticulum, dark brown in colour, is presumably a gland, the lining epithelium of which appears to be quite uneven on the surface abutting on the central lumen (Pl. II, figs. 11, 12, 16; Pl. IV, fig. 1). The thin-walled oesophagus passes below the adductor muscle (Pl. IV, fig. 1), and then runs into the stomach (Pl. III, fig. 3; Pl. IV, fig. 3). The stomach forms an ill-defined chamber which receives the discharge from the liver by a number (7–8) of bile ducts in various length (Pl. III, fig. 3). Both the stomach and the bile ducts have a ciliated epithelium. The liver is well-developed. With the gonad and the genital complex, it forms a voluminous mass which fills up completely the lumen of the visceral sac (Pl. III, figs. 3, 4; Pl. IV, figs. 1, 3, 4). Histologically the liver consists of cubic gland cells lining the central lumens, these latter uniting to pass into the bile ducts. In a living animal, the liver is ashy yellow with scattered black pigment. The rectum is short (Pl. III, fig. 3; Pl. IV, figs. 3, 4). It bends down towards the anus which is postero-lateral in position, as is the case with *Oxynoe* and *Lobiger* (cf. Pl. III, fig. 1; Pl. IV, figs. 6, 7). The inner wall of the rectum is thickly plicate with strong cilia throughout the surface.

Circulatory System: In *Oxynoe* and *Lobiger*, the heart is largely enclosed within the mantle which overlies the visceral sac (Pl. IV, figs. 6, 7; for *Lobiger*, see also PELSENEER, 1894; MARCUS, 1957). It is two-chambered. The belt of the gill-folds runs across the under side of the mantle, immediately behind the heart. An osphradium is accompanied by the gill. Thus the genera *Oxynoe* and *Lobiger* are literally opisthobranchiate; it is assumed that the gill in these forms comes from that in the rather extraordinary members of the Cephalaspidea (cf. *Newnesia* by ELIOT, 1906; *Cylindrobulla* by Ev. MARCUS & Er. MARCUS, 1956). The genus *Tamanovalva* is most intimately allied to *Oxynoe* and *Lobiger* in the essential characters of the heart, the gill and the osphradium. In *Tamanovalva*, however, the visceral sac is markedly compressed laterally, and the right mantle extends down to the level of the foot. The heart is slightly to the right of the median line, lying just below the roof of the visceral sac (Text-fig. 1, C; Pl. III, figs. 1, 5; Pl. IV, fig. 1). The thin-walled auricle is attached to the right mantle and receives blood from the gill. In the cross sections of a preserved specimen, the ventricle, which has a muscular wall, is on the left of the auricle, and the aorta appears to pass into the visceral sac (Pl. III, fig. 5). On the left wall of the visceral sac there are branching sinuses which presumably serve to carry blood to the gill (Text-fig. 1, C, D). The reno-pericardial canal has been given in the previous chapter on the Visceral Sac and the Mantle. There is no spacious haemocoel within the visceral sac.

Genital System: Within the order Sacoglossa, *Tamanovalva* appears to come nearest to *Oxynoe* and *Lobiger*, in the primitive, diaulic type of the genital apertures (see the previous chapter on Soft Part of Body; for *Lobiger*, see also Pelseneer, 1894; Marcus, 1957). In *Tamanovalva*, the ovotestis is a compact gland which lies embedded in the posterior half of the liver, slightly dorsal to the stomach on the left side (Pl. III, fig. 4; Pl. IV, fig. 4). When fresh it is colourless, and can hardly be separated from the tissue of the liver. Young individuals are protandric, but later both eggs and sperms are found in the same gland, the former extremely peripheral and the latter more internal (Pl. III, fig. 6). The ovotestis in *Tamanovalva* is not so differentiated into female and male acini as in *Lobiger*. The hermaphrodite duct develops a swollen and constricted ampulla at about half way of its length (Pl. III, fig. 6). In *Lobiger*, a specialized seminal vesicle is found here (Pelseneer, 1894). Distally the hermaphrodite duct bifurcates into two: the one is the vas deferens and the other the small oviduct. A voluminous prostatic gland is formed round the first part of the vas deferens (Pl. III, fig. 6; Pl. IV, fig. 4). The gland cells take eosin vividly (Pl. III, fig. 7). A prostata is present also in *Lobiger*. After emerging from the prostata, the vas deferens passes forwards through the upper right corner of the foot (Pl. III, fig. 6; Pl. IV, figs. 1, 3); within the lumen of the head and neck it becomes free, and runs into the penis sheath (Pl. III, figs. 4, 6; Pl. IV, fig. 1). The penis sheath is attached to the upper right wall of the neck (Pl. III, fig. 1). The penis is a short flagelliform organ showing a strong curvature at the tip (Pl. III, figs. 6, 8). The vas deferens is a slender canal with internal cilia. A penis sheath is recorded also from *Lobiger*. The small oviduct (Pl. III, fig. 6) leads directly into the large oviduct which forms several convolutions along the entire length of it. Especially strong cilia are borne upon by the small oviduct. The external aperture of the large oviduct is the female orifice (Pl. III, fig. 6). This is found on the right wall of the visceral sac (Pl. III, figs. 1, 4; Pl. IV, fig. 4). Forming the upper right portion of the genital complex is a greatly convoluted accessory female gland which becomes fully developed when the animal is sexually matured (Pl. III, figs. 4, 6). This gland consists of two halves: the upper half is the mucous gland which stain blue with Delafield's haematoxylin (Pl. III, fig. 6); the lower half, extending further behind the mucous gland, forms an albumen gland packed with coarse, eosinophile granules (Pl. III, fig. 6). The mucous gland and the albumen gland discharge into the large oviduct, close to the entrance of the small oviduct. The vagina arises from the large oviduct as a straight canal ciliated internally (Pl. III, fig. 6). Distally it is communicated with a spermatheca and a spermatocyst, the former being decidedly larger than the latter (Pl. III, fig. 6). These two vesicles are also recorded from *Lobiger*. In *Tamanovala*, there is an external oviducal groove on the right side of the head and neck (see the previous chapter on Soft Part of Body).

III. The Affinity of the Bivalved Sacoglossans

From the anatomical comparisons given above, it may be deduced that the mollusc *Tamanovalva* is most closely allied to *Oxynoe* and *Lobiger* by the similarity of the organs as follows: (1) the gill formed of thin, longitudinal folds on the under side of the right mantle; (2) the osphradium accompanied by the gill; (3) the kidney enclosed within the right mantle and situated above the gill; (4) the sacoglossan teeth with fine denticulations on both sides (*Oxynoe*); (5) the male orifice widely separated from the female one; (6) the internal vas deferens leading directly into the penis sheath; and (7) the genitalia with two vesicles (spermatheca and spermatocyst).

But there exist a series of peculiarities distinguishing *Tamanovalva* from both of, or either of, the two genera, *Oxynoe* and *Lobiger*.

Oxynoe	*Lobiger*	*Tamanovalva*
1. With a pair of parapodia.	1. With two pairs of parapodia.	1. Without parapodia.
2. Tail very long.	2. Moderately long.	2. Very short.
3. Without oral tentacles.	3. With oral tentacles.	3. With oral tentacles.
4. Eyes widely separated.	4. Same as in *Oxynoe*.	4. Close together.
5. Without an external oviducal groove; male orifice below right rhinophore.	5. Same as in *Oxynoe*.	5. With an external oviducal groove; male orifice on right side of neck.
6. Shell single, bulloid, of the snail type.	6. Single, of the snail type, but depressed and like half of a bivalve.	6. Originally single, of the snail type, but later becoming bivalved.
7. Heart slightly to the left of the median line.	7. Submedian.	7. Slightly to the right of the median line.
8. Hypobranchial gland within the right mantle behind the gill.	8. Same as in *Oxynoe*.	8. Hypobranchial gland on the postero-lateral wall of the visceral sac.
9. With a "ciliated ridge" on mantle and on visceral sac posteriorly.	9. Without a "ciliated ridge".	9. With a "ciliated ridge" on mantle and on visceral sac posteriorly.
10. Body swollen in cross section.	10. Same as in *Oxynoe*.	10. Greatly compressed laterally.
11. Nerve ganglia highly centralized, visceral loop very shortened.	11. Same as in *Oxynoe*.	11. Not highly centralized, visceral loop very long.

Within the order Sacoglossa¹⁾, the Tamanovalvacea KAWAGUTI & BABA, 1959 is retained here as distinct from the Oxynoacea. A brief definition of the Tamanovalvacea is given below:

With a typical sacoglossan radula. Soft part of body snail-shaped, but the visceral sac is greatly compressed from side to side; a bivalved shell, the apex of the left valve planted with a helicoid shell of the gastropod veliger. Genital orifices primitively diaulic; an external oviducal groove on the right side of the head and neck. A gill, an osphradium and a kidney approximately as in Oxynoacea. Nerve ganglia not highly centralized, having a long visceral loop.

Possibilities of the congeneric identity of *Tamanovalva* with *Edenttellina*, with *Ludovicia*, or further with *Berthelinia*, have recently been suggested. All these genera cited above resemble each other in having a bivalved shell or a helicoid protoconch at the apex of the left valve. Strictly speaking, *Tamanovalva* is distinct from *Edenttellina* in the characters of the shell and radula (see the comparison tables given previously). Based merely on the relative position of the protoconch to the shell proper, *Edenttellina* comes nearest to *Ludovicia* rather than to *Tamanovalva*, and this latter, in turn, may be linked with *Berthelinia*. But at present it is not easy to establish a certain satisfactory identification of our living animals with such fossil remains as from the Parisian Tertiary.

If all of these genera (*Tamanovalva*, *Edenttellina*, *Ludovicia* and *Berthelinia*) are to be united in a single genus, the pioneer generic name is *Berthelinia*; our species will be renamed as *Berthelinia limax* (KAWAGUTI & BABA). The family name will also be changed: Bertheliniidae (=Tamanovalvidae).

The genus *Berthelinia* thus identified may comprise *Midorigai* as its congeneric member (see the comment given in the postscript). The recent species

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1) The members of the Sacoglossa may have had their ancestral origin within the Cephalaspidea (possibly not within the Notaspidea; cf. ODHNER, 1934, 1939). But the anatomical features shown by the present-day sacoglossans are so varied according to the families and genera they classified in that we feel somewhat difficult in finding what the monophyletic evolution from the lower Cephalaspidea to the diversified Sacoglossa really is. A systematic synopsis of the sacoglossan suborders runs as follows:

I. Subord. Oxynoacea.
    Fam. Oxynoidae. *Oxynoe*, *Lobiger*. A marked centralization of the nervous system. Shell bulloid or depressed. With parapodia. Radula and gill probably related to those in *Newnesia* and *Cylindrobulla* (Cephalaspidea). Diaulic genital orifices roughly as in *Actaeon* (Cephalaspidea), without an external seminal groove.
    Fam. ……………. *Arthessa*. Primitive in the somewhat streptoneurous nervous system. A bulloid shell distinct in having a posterior spout. No parapodia. A sacoglossan radula.
II. Subord. Tamanovalvacea. Primitive in the somewhat streptoneurous nervous system; specialized rather aberrantly in the bivalved shell and in the lateral compression of the body. For the other characters, see the definition of the suborder.
III. Subord. Elysiacea. Advanced in the multiform external aspects. A highly centralized nervous system. Shell disappeared. Genital orifices triaulic.

of *Berthelinia* so far recorded from the world are[1]: 1. *B. typica* (GATLIFF & GABRIEL, 1911); 2. *B. corallensis* (HEDLEY, 1920); 3. *B. australis* (BURN, 1960); and 4. *B. limax* (KAWAGUTI & BABA, 1959).

The following is a concise characterization of our species from Japan (*B. limax*):

Shell small, up to 8 mm in length, elongate-oval in side view, inflated and rather strongly convex, posterior end rounded, umbos at the latter one-third of the shell-length, themselves not elevated greatly; extremely thin and translucent, of a pale yellowish green or yellowish white, the surface smooth with very fine growth-lines crossed by indefinite radiating threads; periostracum colourless, pearl layer shining. The left and right valves almost equal in size, shape and convexity, combined dorsally by a faintly ashy yellow ligament over which is a contiguous layer of periostracum; each valve forming an elongated hinge-plate below the umbo; the two valves articulated at the front and rear ends of the hinge by cardinal teeth and corresponding sockets. The helicoid protoconch at the apex of the left valve small, inclined nearly horizontally, extending over the right valve. An adductor muscle scar in the anterior half of each of the valves.

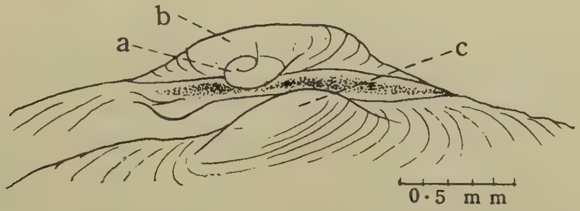

Fig. 3. *Midorigai australis* (Torquay, Victoria, Nov. 21, 1960, shell-length 4.6 mm). Umbonal region of the paired (slightly detached) valves. a. protoconch, b. umbo of the left valve, c. umbo of the right valve.

Largest animal when fully extended, about 12 mm in length. Soft part of body snail-shaped, the head with auriculate rhinophores and lobiform oral tentacles; paired eyes close together, the eye-region forming a small projection on the neck in the middle line. Foot narrow, the sole flat but easily folded longitudinally along the median line; tail very short. Male orifice on the right side of the neck, female orifice far back on the right wall of the visceral sac, an external oviducal groove running below the male orifice to the outer base of the right oral tentacle. Visceral sac completely within the shell; it is greatly compressed from side to side. Mantle in two unequal lobes, the two hunging down to the level of the foot. Mantle-margin double (cleft in two leaflets), clinging to the border of the shell. Gill formed of thin, longitudinal folds on the under side of the right mantle; an osphradium accompanied by the gill; a kidney enclosed within the right mantle. Between the right mantle and the visceral sac there is a deep mantle cavity. Anus postero-lateral. Hypobranchial gland on the surface of the visceral sac, posterior to the anus; with a "ciliated ridge" on the rear wall of the visceral sac and on the under side of the right mantle, posterior to the gill. A horizontal adductor muscle running across the former one-third of the visceral sac. Pharyngeal bulb with paired sac-like crops and paired, exceedingly elongated, salivary glands. An oesophageal diverticulum. Radula teeth about 5–7 in the ascending series, and 30–35 in the descending spiral series; each tooth simple at tip, the blade denticulated on both edges. Liver voluminous, almost filling up the visceral sac. Nervous system roughly as in the primitive Opisthobranchia: the paired cerebro-pleural and the paired pedal ganglia are centralized round the oesophagus, the rest of the ganglia (infra-intestinal, supra-intestinal and visceral) are distributed along the course of the visceral loop; a statocyst on each of the pedal ganglia. Heart two-chambered, slightly to the right of the median line. A reno-pericardial canal. A single ovotestis. Hermaphrodite duct forming an ampulla; vagina with two vesicles (spermatheca and spermatocyst); a prostate gland round the first part of the vas deferens, a penis sheath within the lumen of the head and neck, penis short flagelliform, curved at the tip, without armatures. Genital apertures primitively diaulic with male orifice and female (oviducal) orifice, vagina joined with the oviduct, vas deferens internal throughout. Body vivid grass-green almost everywhere, ornamented with opaque white dots on rhinophores, on head and on mantle-margin; grass-green colour of the mantle shining through the shell, sole paelr than body, gill-folds yellow. Mantle not red pigmented. Animal feeding on submerged green alga, *Caulerpa okamurai*. Distributed in the Inland Sea of Seto (common), and in Toyama Bay, Japan Sea (rare).

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[1] The American species and subspecies published lately are: *B. chloris* DALL, 1918 and *B. c. belvederica* KEEN & SMITH, 1961. Seemingly they are closely allied to *B. limax* in the small and inclined [type of the] the protoconch (and finely denticulated radula teeth); they may be separated from our species by the different shape of the shell.

Postscript

1. A specimen designated as a "paratype" of *Midorigai australis* (Flinders, Victoria, Mar. 20, 1960) was offered by Mr. BURN in May, 1960. It appeared then to me distinct in having smooth radula teeth; now it has been suggested by him to be identified with *Berthelinia typica* (GATLIFF & GABRIEL).

2. A brief account of the Victorian specimen before me runs as follows (Pl. I, figs. 9–10; Pl. II, figs. 5, 10): the shell (about 2.5 mm long and 1.6 mm high) is elongate-oval; it is more rounded behind than in *B. limax*. The protoconch is small (as in *limax*), inclined, of 1 ½ whorls, and placed at the latter one-fourth of the shell-length, the general appearance of the shell proper being

thus very inequilateral. The two valves are articulated as in *limax*. The ligament is dark brown. The umbos of the shell are not prominent. Externally the shell is pale yellowish green, and not marked with radiating, dark green bands. The soft part of the body is organized as in *limax* (the adductor, the male and female orifices, the external oviducal groove, etc.). The radula contains about 6 teeth in the ascending series, and 23 teeth in the descending one. All the teeth are distinctly bifid at the tip; all of them show no trace of lateral denticulations. Certainly this is referable to *typica* of GATLIFF & GABRIEL in the shape of the shell.

3. A new form, *Midorigai australis*, was proposed by Mr. BURN in July, 1960. He placed 8 specimens of his collections of this species (Torquay, Victoria, Nov. 21, 1960) at my disposal for the comparative study in January, 1961. The largest specimen (Text-fig. 3; Pl. I, figs. 11–13) had the shell about 4.6 mm long and 2.8 mm high. The shell is elongate-quadrangular, inflated, of a pale yellowish green, and with broad, radiating, dark green bands showing through the transparent periostracum. The umbos are very prominent, the left umbo being greatly elevated and higher than the right one. The protoconch, situated at about the latter one-third of the shell-length, is small, and inclined completely to a horizontal plane. The two valves are articulated at the hinge as in *B. limax* and *B. typica*; they do not differ considerably in dimension from each other. The ligament is ashy brown. The radula teeth (ascending 7, descending 35 or more) are simple at the tip and provided with distinct denticulations on each of them. The adductor muscle is single. The situation of the genital orifices, the possession of the external oviducal groove, the general musculature, and the main characters of the internal anatomy in *Midorigai* are essentially as given for *limax* (for microscopical comparisons, two young individuals of *Midorigai* were examined in serial transverse preparations). Now the genus *Midorigai* may not be maintained as different fundamentally from *Berthelinia*.

4. A specimen labelled as *Berthelinia typica* (Torquay, Victoria, Mar. 5, 1960) was presented by Mr. BURN in May, 1960. By examining the Victorian specimen, I was able to separate *typica* in question from our species, *limax*, by a series of distinctions. Unfortunately this view of mine has been neglected by Mr. BURN (cf. BURN, 1960b). Anyhow, the species *typica* BURN, 1960, is requested to be re-identified by itself, or in relation to *typica* (VERCO, 1916; HEDLEY, 1920), or to *corallensis* (HEDLEY, 1920). A short characterization of the Victorian specimen of *B. typica* BURN is shown below: The shell (about 4 mm long and 2.6 mm high) is rather solid, flattened (slightly convex), and vivid yellowish green in colour. The umbos are not prominent. The general shape of the shell is almost as in *typica* (VERCO; HEDLEY) and *corallensis*: the valves are suddenly narrowed and pointed behind. The protoconch, situated at the latter one-third of the shell-length, is very large (about twice as large as that of *limax*), of 1½ whorls,

and nearly vertical. The articulations of the two valves appear to be well-marked. The ligament is dark brown. The radula teeth (ascending 6, descending 34) are finely denticulated; each of them is bifid at the tip. The soft part of the body is organized as in *limax* (the adductor, etc.).

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EXPLANATION OF PLATES I–IV

PLATE I

Fig.s 1–8. *Tamanovalva limax.*

Figs. 1A–1B. Paired valves (Tamano, Inland Sea of Seto, Aug. 20, 1959, shell-length 4 mm). 1A. Left valve from outside; 1B. Right valve from outside.

Figs. 2A–2B. The same as before. 2A. Left valve from inside; 2B. Right valve from inside.

Figs. 3A–3C. Umbonal region of a paired shell (shell-length 5 mm). Showing a small, inclined protoconch extending over the right valve. 3A. Protoconch from left side; 3B. Protoconch and right umbo from right side; 3C. Protoconch and hinge from above.

Figs. 4A–4B. Hinge from inside (shell-length 4 mm). 4A. Right valve; 4B. Left valve.

Figs. 5A–5B. Paired valves from inside (shell-length 7 mm). Showing actual position of the various muscle scars by black spots at the corresponding places. 5A. Left valve; 5B. Right valve.

Fig. 6. Entire row of radula teeth.

Fig. 7. A youngest bivalve (shell-length 0.7 mm), from left side.

Fig. 8. A slightly advanced bivalve (shell-length 1.2 mm), from left side.

Figs. 9–10. *Edenttellina typica* G. & G.

Figs. 9A–9B. Left valve from outside and inside (Flinders, Victoria, Mar. 20, 1960, shell-length 2.5 mm).

Fig. 10. Part of a radula row.

Figs. 11–13. *Midorigai australis.*

Fig. 11. A paired shell from right side (Torquay, Victoria, Nov. 21, 1960, shell-length 4.6 mm).

Figs. 12A–12B. Hinge from inside. 12A. Right valve; 12B. Left valve.

Fig. 13. Part of a radula row.

Figs. 14A–14B. *Berthelinia elegans* (Paris Basin Eocene, adopted from CROSSE, 1875, Pl. 2, fig. 3, shell-length 0.5 mm). Recorded as a gastropod. 14A. Left valve from outside; 14B. Left valve from inside.

Figs. 15A–15B. *Berthelinia elegans* (Paris Basin Eocene, adopted from CROSSE & FISCHER, 1887, pl. 10, figs. 1a, 1c, shell-length 1.2 mm). Recorded as a bivalve. 15A. Left valve from outside; 15B. Left valve from inside.

Figs. 16A–16B. *Berthelinia elegans* (Paris Basin Eocene, adopted from Cossmann, 1888, pl. 7, figs. 28–29, shell-length 2.5 mm). Recorded as a bivalve. 16A. Right valve from outside; 16B. Right valve from inside.

Figs. 17A–17B. *Berthelinia elegans*, var. *elata* (Paris Basin Eocene, adopted from Cossmann, 1888, pl. 7, figs. 26–27, shell-length 2.5 mm). Recorded as a bivalve. 17A. Left valve from outside; 17B. Left valve from inside.

Figs. 18A–18B. *Ludovicia squamula* (Paris Basin Eocene, adopted from Cossmann, 1888, pl. 2, figs. 21–22, shell-length 15 mm). Recorded as a bivalve. 18A. Left valve from outside; 18B. Left valve from inside.

Figs. 19A–19B. *Anomalomya corrugata* (Paris Basin Eocene, adopted from Cossmann, 1888, pl. 7, figs. 30–31, shell-length 5.5 mm). Recorded as a bivalve. 19A. Right valve from outside; 19B. Right valve from inside.

Figs. 20A–20B. *Edenttellina typica* (Victoria, adopted from Gatliff & Gabriel, 1911, pl. 46, fig. 6, shell-length 3 mm). Recorded as a bivalve. 20A. Right valve from inside; 20B. Left valve from inside.

Figs. 21A–21B. *Edenttellina corallensis* (North Queensland, adopted from Hedley, 1920, figs. 7–8, shell-length 5 mm). Recorded as a bivalve. 21A. Left valve from outside; 21B. Left valve from inside.

PLATE II

Figs. 1–4, 6–9, 11–16. *Tamanovalva limax*; Figs. 5, 10. *Edentttellina typica* G. &. G.

Fig. 1. An extended animal (Tamano, Inland Sea of Seto, Aug. 20, 1959, shell-length 6 mm, total length of animal about 10 mm).

Fig. 2. Umbonal region of a paired shell (shell-length 4.5 mm). Showing a small, inclined protoconch, from left side. a. protoconch, b. umbo of the right valve.

Fig. 3. The same as before, from right side

Figs. 4A–4B. Hinge from inside (shell-length 4 mm; the same as Pl. I, figs. 4A–4B). X. The front; Y. The rear. 4A. Right valve; 4B. Left valve. a. hinge-plate, b. ligament, c. protoconch, d. anterior cardinal to the right valve, e. corresponding socket to the left valve, f. posterior cardinal to the right valve, g. corresponding socket to the left valve, h. posterior cardinal to the left valve, i. corresponding socket to the right valve.

Figs. 5A–5B. Hinge from inside (shell-length 2.5 mm). 5A. Right valve; 5B. Left valve. Letters as in Figs. 4A–4B.

Figs. 6A–6B. Hinge in the median line from above (shell-length 6 mm). Showing a small, inclined protoconch extending over the right valve. X. The front; Y. The rear. 6A. Left valve; 6B. Right valve. a. protoconch of the left valve, b. ligament between the left and right hinge-plates, c. anterior articulation, d. umbo of the right valve, e. posterior articulation.

Figs. 7A–7B. Hinge in the median line from below. The protoconch is hollowed to the tip. a. anterior articulation, b. posterior cardinal to the left valve (7B), c. posterior cardinal to the right valve (7A).

Fig. 8. Part of the cross section of the visceral sac in about the middle of the hinge-length. a. median hinge-groove of the visceral sac, b. ligament taking eosin, c. periostracum staining with DELAFIELD's haematoxylin. The calcareous and pearl layers of the shell are dissolved by the fixing fluid.

Fig. 9. A radula tooth (×400).

Fig. 10. A radula tooth (×750).

Fig. 11. Pharynx and the nervous system from a fresh specimen, in dorsal view. Slightly diagrammatized by separating the two salivary glands from each other. a. oesophagus, b. buccal ganglion, c. cerebro-pleural ganglion, d. pharyngeal crop, e. pedal ganglion, f. right pleuro-visceral connective, g. oesophageal

diverticulum, h. supra-intestinal ganglion, i. osphradial ganglion (supplemented with serial sections), j. visceral ganglion, k. genital ganglion, l. infra-intestinal ganglion, m. left pleuro-visceral connective, n. glandular portion of the salivary gland, o. duct of the salivary gland, p. pharynx.

Fig. 12. Pharynx and the nervous system from right side. a. ascending series of radula, b. pharynx, c. mouth slit, d. descending series of radula, e. ascus, f. pharyngeal crop, g. buccal ganglion, h. pedal ganglion, i. left pleuro-visceral connective, j. salivary gland, k. infra-intestinal ganglion, l. oesophagus, m. genital ganglion, n. visceral ganglion, o. supra-intestinal ganglion, p. oesophageal diverticulum, q. right pleuro-visceral connective, r. cerebro-pleural ganglion.

Fig. 13. Pharynx and the nerve ring in ventral view. a. pharynx, b. ascus, c. salivary gland, d. oesophagus, e. cerebro-pleural ganglion, f. pedal ganglion, g. pharyngeal crop, h. buccal ganglion.

Fig. 14. Cross section of a pharyngeal crop (×150).

Fig. 15. Cross section of a salivary gland (×150). The secretory cells stain deeply with haematoxylin.

Fig. 16. Part of the wall of the oesophageal diverticulum (×300).

PLATE III

Figs. 1–8. *Tamanovalva limax.*

Fig. 1. Naked animal in a contracted state, from right side. a. ventricle, b. auricle, c. right head retractor, d. penis sheath retractor, e. right foot retractor, f. eye, g. penis sheath, h. rhinophore, i. oral tentacle, j. external oviducal groove, k. male orifice, l. foot, m. adductor muscle, n. female orifice, o. tail, p. left mantle, q. anus, r. "ciliated ridge" on the left mantle, r′. "ciliated ridge" on the under side of the right mantle, s. hypobranchial gland, bland, t. right mantle, u. gill-folds on the under side of the right mantle, v. nephroproct on the under side of the right mantle, w. osphradium within the right mantle.

Fig. 2. Cross section through the elevated eye-region (×130). a. false cornea, b. lens, c. retina.

Fig. 3. Diagrammatic representation of the digestive system in the body. All the structures are drawn in a horizontal plane. a. eye, b. cerebro-pleural ganglion, c. oesophagus, d. supra-intestinal ganglion, e. osphradial ganglion, f. osphradium, g. anus, h. hypobranchial gland, i. "ciliated ridges", j. mucous gland cells, k. right tail retractor, k′. left tail retractor, l. transverse visceral muscle, m. liver, n. bile ducts, o. stomach, p. infra-intestinal ganglion, q. periostracum of the shell, r. pharynx.

Fig. 4. Diagrammatic representation of the genital system in the body. All the structures are shown in a horizontal plane. a. penis sheath, b. penis, c. right foot retractor, d. female orifice, e. gill-folds, f. kidney, g. mantle cavity, h. right mantle, i. eosinophile unicellular gland cells of the mantle margin, j. ovotestis, k. visceral ganglion, l. adductor muscle, m. left foot retractor, n. head, o. rhinophore.

Fig. 5. Cross section of the visceral sac through the heart (×60). a. pericardium, b. auricle, c. gill-folds, d. liver diverticula, e. aorta, f. ventricle.

Fig. 6. Diagrammatic representation of the genital system shown in a horizontal plane. From a matured specimen about 5 mm in shell-length. a. penis sheath, b. penis, c. female orifice, d. large oviduct, e. vagina, f. mucous gland, g. small oviduct, h. vas deferens, i. prostata, j. ovotestis, k. hermaphrodite duct, l. albumen gland, m. ampulla, n. spermatocyst, o. spermatheca.

Fig. 7. Part of the prostata (×120). a. gland cells, b. vas deferens.

Fig. 8. Cross section of the penis (×230).

PLATE IV

Figs. 1–5. *Tamanovalva limax.* The serial cross sections (figs. 1, 3, 4) were prepared from a young individual about 3 mm in shell-length.

Fig. 1. Cross section of the body approximately along the vertical line A–A of Pl. III, fig. 1, viz.: through the middle of the adductor muscle. The head is so greatly contracted in the fixing fluid that the pharynx and the penis sheath come to overlie the adductor. a. ventricle, b. reno-pericardial canal, c. origin of the right pharyngeal crop, d. penis, e. cerebro-pleural ganglion, f. penis sheath, g. oesophageal diverticulum, h. origin of the right foot retractor, i. supra-intestinal ganglion, j. osphradial nerve, k. adductor muscle, l. right pleuro-visceral connective, m. vas deferens, n. aggregated pedal glands, o. oesophagus, p. left pleuro-visceral connective, q. salivary gland, r. infra-intestinal ganglion, s. left pharyngeal crop, t. origin of the left foot retractor, u. pharynx, v. aorta, w. liver, x. periostracum of the shell.

Fig. 2. Part of the right mantle to show the reno-pericardial canal in Fig. 1 (×300). a. kidney, b. gill-fold, c. reno-pericardial canal.

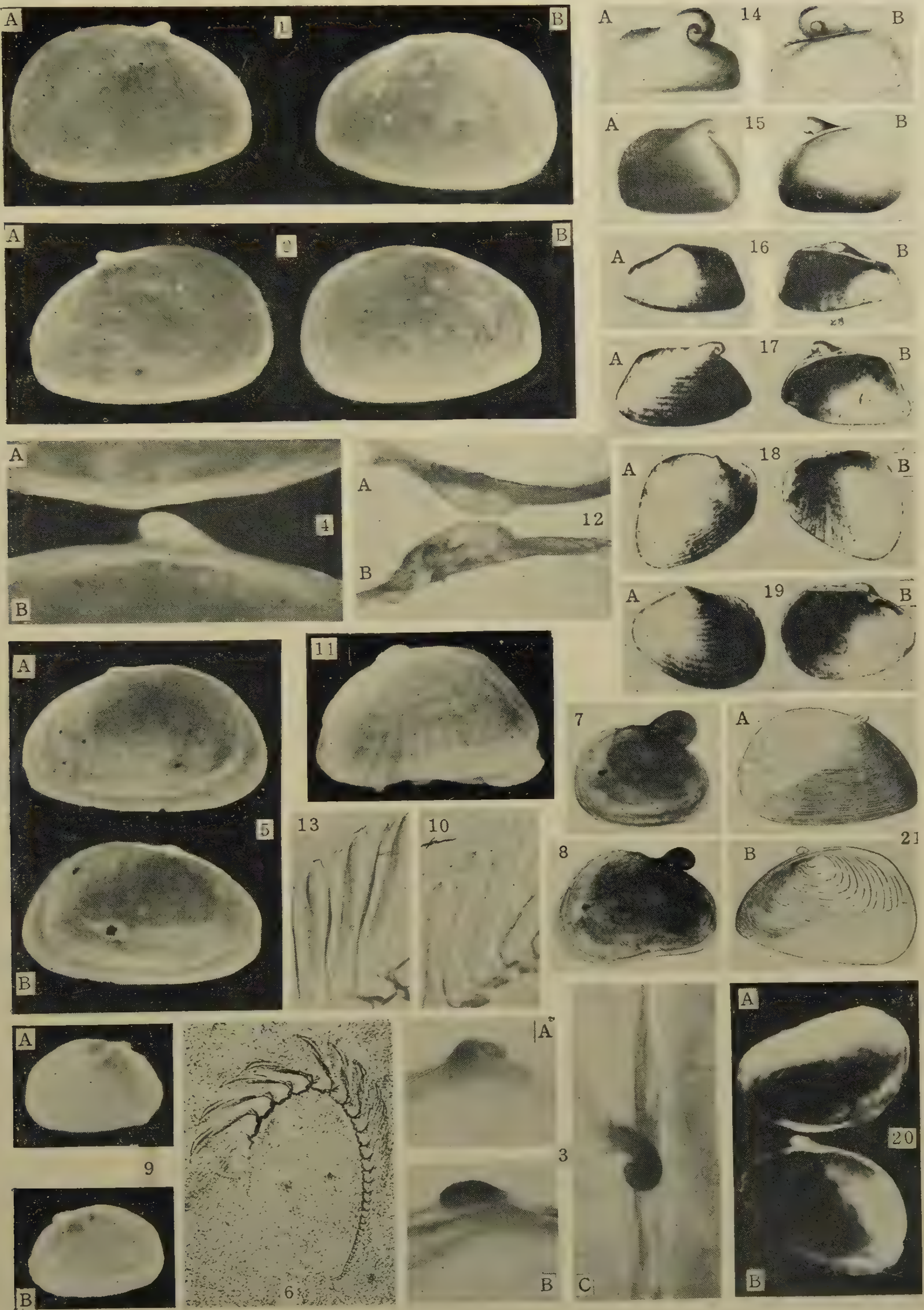
Fig. 3. Cross section approximately along the vertical line B–B of Pl. III, fig. 1, viz.: through the visceral ganglion which is immediately behind the adductor. a. gill-folds, b. rectum about to start from the stomach, c. kidney, d. accessory female gland not fully differentiated, e. mantle cavity, f. visceral ganglion, g. osphradial ganglion, h. osphradium, i. vas deferens, j. right mantle, k. left mantle, l. prostata, m. oesophagus about to run up into the stomach, n. ampulla, o. spermatheca, p. stomach, q. ovotestis.

Fig. 4. Cross section approximately along the vertical line C–C of Pl. III, fig. 1, viz.: through the female orifice and the genital complex. a. "ciliated ridge", b. rectum, c. accessory female gland about to open into the large oviduct, d. small oviduct about to join with the large oviduct (e), f. duct of the spermatheca, g. duct of the spermatocyst (h), i. female orifice, j. genital ganglion, k. prostata, l. ampulla, m. hermaphrodite duct, n. stomach, o. ovotestis.

Fig. 5. Part of the right mantle to show the nephroproct opening into the mantle cavity (×300). a. renal cells, b. nephroproct.

Fig. 6. *Oxynoe viridis* (Misaki, Sagami Bay, Aug. 29, 1951, total length of animal 25 mm). General organization from the dorsal side. Slightly diagrammatic. a. rhinophore, b. male orifice, c. female orifice below the right mantle, d. parapodial lobes, e. osphradium within the right mantle, f. gill-folds on the under side of the right mantle, g. hypobranchial gland within the right mantle, h. anus on the right wall of the visceral sac, i. "ciliated ridge" on the under side of the right mantle, j. auricle, k. ventricle, l. pericardium, m. outline of the mantle overlying the visceral sac, n. eye.

Fig. 7. *Lobiger sagamiensis* (Misaki, Sagami Bay, Aug. 24, 1951, total length of animal 10 mm). General organization from the dorsal side. Slightly diagrammatic. a. male orifice, b. pericardium, c. osphradium, d. female orifice, e. hypobranchial gland, f. anus, g. gill-folds, h. ventricle, i. outline of the mantle, j. eye, I–II. parapodial lobes.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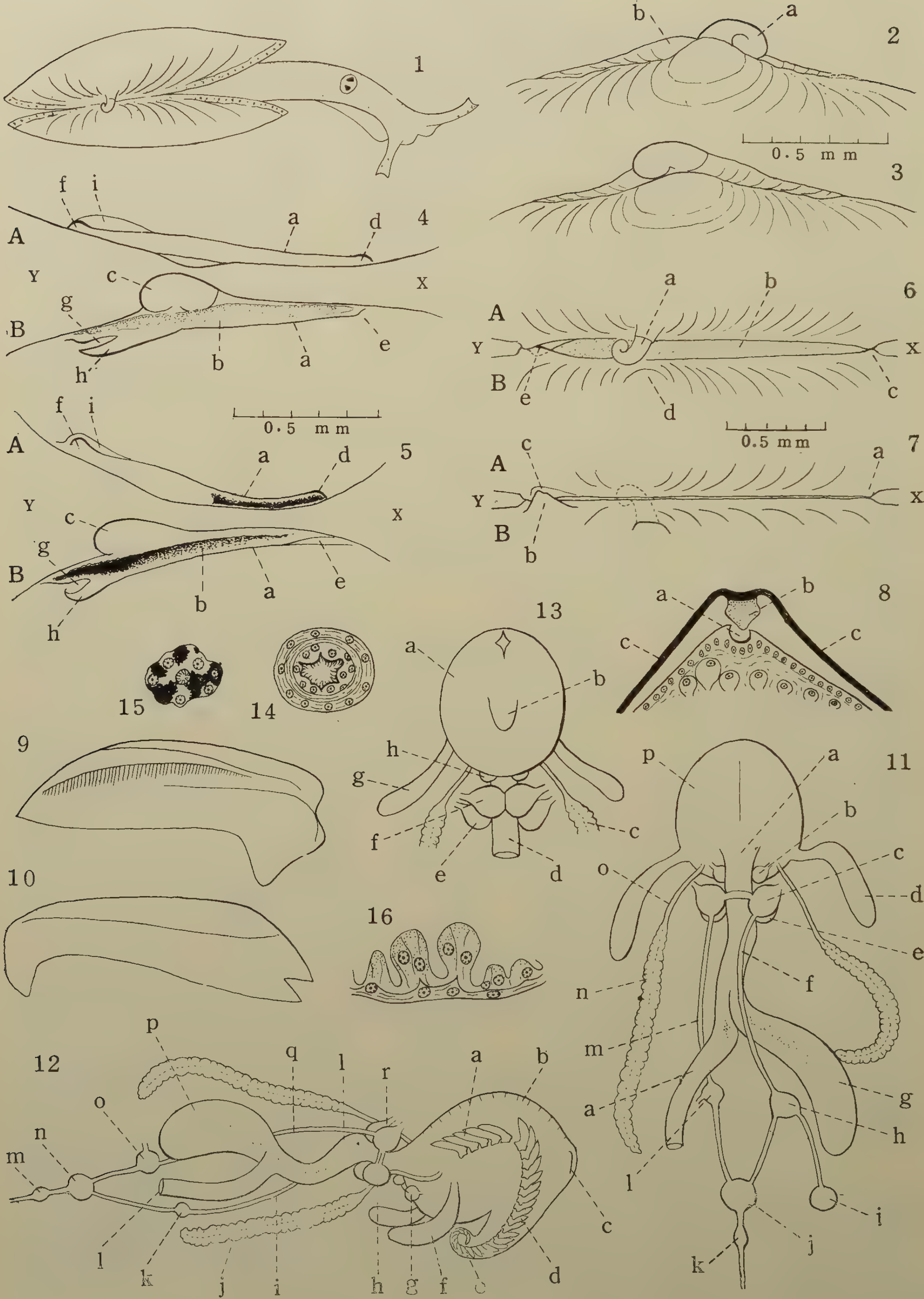
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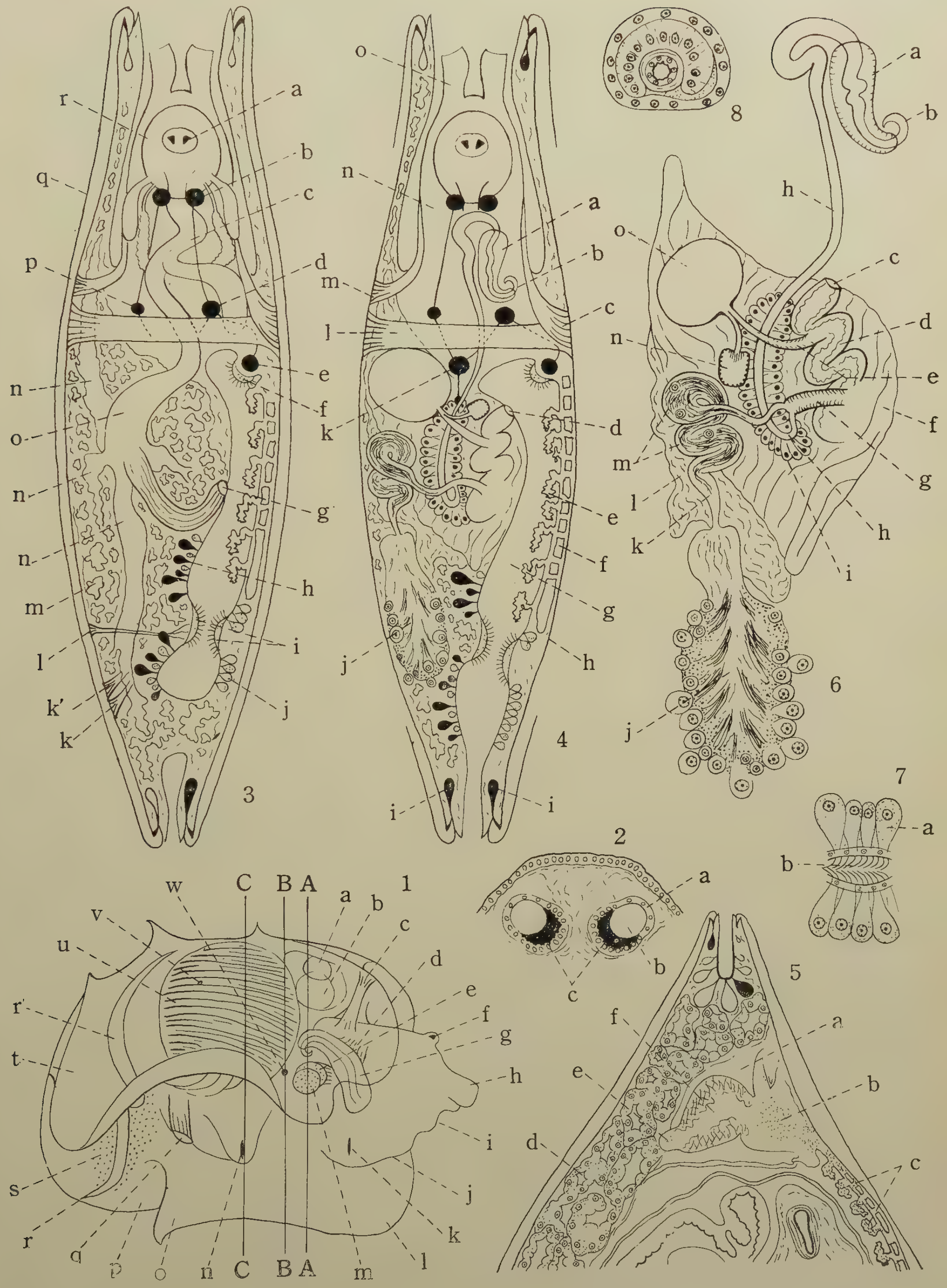
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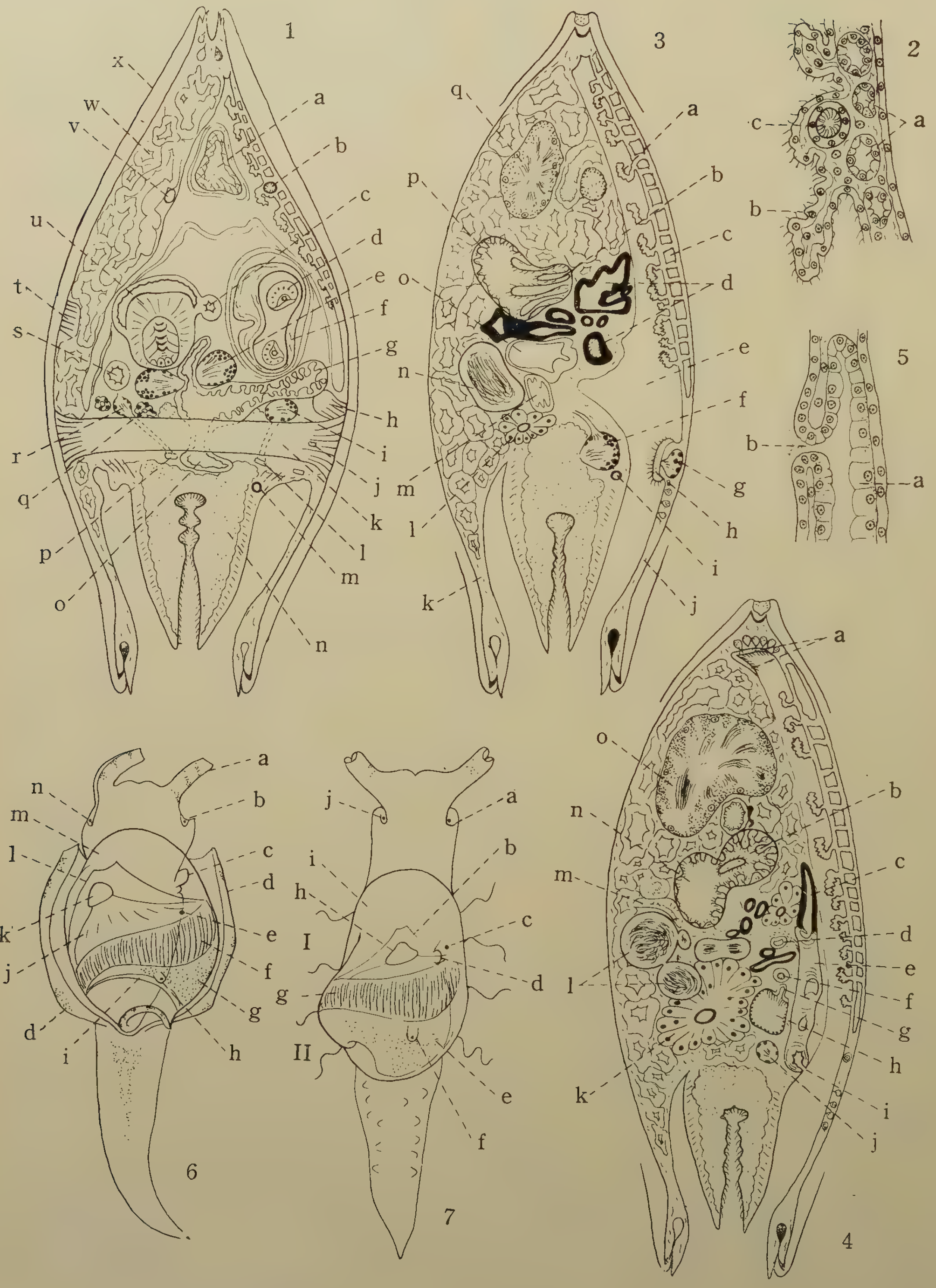
K. BABA: IDENTIFICATION AND AFFINITY OF *TAMANOVALVA LIMAX.*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K. Baba: Identification and Affinity of *Tamanovalva limax*.

ON TWO SPECIES OF *DORIOPSIS* (SYN. *CTENODORIS*) FROM JAPAN (NUDIBRANCHIA-DORIDIDAE)[1]

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With 1 Text-figure

The genus *Doriopsis* Pease, 1860 (Syn. *Ctenodoris* Eliot, 1907; *Guyonia* Risbec, 1928) is especially marked by having simply pinnate gills in a transverse row, and a crescentic gill cavity. The known members of the genus appear to differ from one another mainly in colour; they may tentatively be arranged as follows:

Yellow forms:
Doriopsis granulosa Pease, 1860. Hawaii.
Doriopsis scabra Pease, 1871. Tahiti.
Doriopsis aurantiaca (Eliot, 1913). Japan.
Doriopsis flava (Risbec, 1928). New Caledonia; New South Wales; ? Maldive.
Doriopsis flabellifera (Cheeseman, 1881). New Zealand.
Dark green form:
Doriopsis viridis Pease, 1861. Tahiti; New Caledonia.
Blue form:
Doriopsis pecten (Collingwood, 1881). Keelung; New Caledonia; New South Wales.

It is questionable whether each of the yellow forms stands specifically valid. As to the dark green form and the blue one, they are assumed by Risbec (1928, 1953) to be varieties of a single species (see also Allan, 1947).

Doriopsis aurantiaca (Eliot, 1913)

Kiiro-kushiera-umiushi

Doris (*Ctenodoris*) *aurantiaca* Eliot, 1913, pp. 5–7, pl. 1, fig. 1.—Sagami Bay (Misaki).
Ctenodoris aurantiaca Baba, 1937, pp. 301–302, text-fig. 5.—Amakusa (Tomioka); Baba, 1949, pp. 63, 150, pl. 24, fig. 87, text-fig. 76.—Sagami Bay (Hayama).

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1) Contributions from the Seto Marine Biological Laboratory, No. 361.

Publ. Seto Mar. Biol. Lab., IX (1), 1961. (Article 5)

Total length up to 35 mm. Back covered everywhere with obtuse granules of various sizes. Gills 11–20. Dorsum always of a citron yellow, the granules indistinctly dotted with chocolate, under side of body paler than above. For the radula, see BABA, 1937, 1949. Animal may sometimes be found from above the yellow sponge colony (BABA, 1937). Spawns obtained in September, 1955, from Osaka Bay, citron yellow, about 4 1/2 convolutions, measuring ca. 35 mm across the whole mass in surface view; the egg-capsules containing 1 (–2) eggs (diameter of the egg-cell ca. 100μ) in each.

Dist.: Sagami Bay (Misaki; Hayama); Kii; Osaka Bay; Amakusa; Toyama Bay. Common.

Doriopsis aurantiaca is very closely allied to *D. granulosa* in the yellow colour of the body, but in the latter species the dorsal granules are said to be green; for the present, the species *aurantiaca* is separated from *granulosa*.

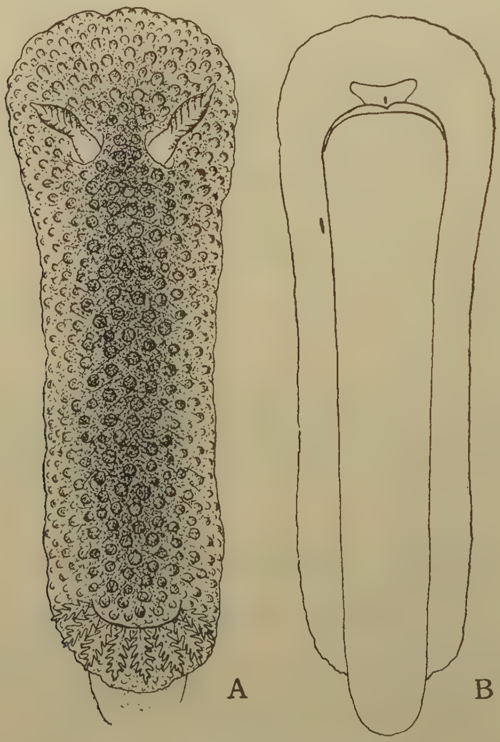

Fig. 1. *Doriopsis viridis.*
A. Animal from above; B. Animal from below.
Hatakejima, Kii, July 23, 1960, length 7 mm.

Doriopsis viridis PEASE, 1861

Ao-kushiera-umiushi

(Fig. 1)

Doriopsis viridis PEASE, 1861, pp. 244–245.—Tahiti; PEASE, 1871, p. 301, pl. 19, fig. 1.
Doris pecten COLLINGWOOD, 1881, p. 126, pl. 9, figs. 1–5.—Keelung.
Guyonia viridis RISBEC, 1928, pp. 105–106, pl. 3, fig. 4 (variété bleue).—New Caledonia.
Doriopsis viridis RISBEC, 1953, pp. 44–45 (variété bleue).—New Caledonia; ALLAN, 1947, p. 449, pl. 42, fig. 5.—New South Wales.

Total length 7–10 mm. Back covered as usual with spiculate, obtuse granules. Gills 8–9. General body-colour above indigo blue, somewhat deeper on the top of the granules. Rhinophores and gills also indigo blue. Under side of body paler than above, sole whitish. Mouth part without labial plates. Radula formula 30×30.0.30, all of the lateral teeth simply hamate. Animal found living on a blue sponge colony.

Loc.: Hatakejima, Tanabe Bay, Kii (July 1960, 3 sps., coll. by Dr. Isamu YAMAZI).

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NOTES ON VELIGERS OF JAPANESE OPISTHOBRANCHS (3)[1, 2]

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With 10 Text-figures

Succeeding my previous papers on the veligers of seven Japanese opisthobranchs, here is presented the third paper of the same series in which the following three species are treated: they are *Philine japonica* LISCHKE and *Doridium giglioli* (TAPPARONE-CANEFRI) of Philinacea, both collected from the *Zostera*-zone at Tannowa on the southeastern coast of Osaka Bay, and *Goniodoris sugashimae* BABA of Okeniidae (=Goniodorididae) caught at Kada situated about 9.5 km southwest to Tannowa. The observations were made on egg-masses spawned in my private laboratory by animals collected at the above-mentioned localities.

Philine japonica LISCHKE

(Figs. 1–3)

Descriptions including some figures on this opisthobranch were recently given by following two papers: HAMADA and INO (1957) made clear the feeding and spawning habits and the destribution of this animal in Tokyo Bay and TANAKA (1958) described on the pelagic larva and gave figures of its shell. However, the detailed morphological descriptions and figures of the newly hatched veliger of this species has never been given by any workers. So, the present author is going to give here some biological notes of this animal and the details of morphological observations of the newly hatched veliger.

This species is 25 to 30 mm in length, light grayish white faintly with a yellowish tint, and can be found commonly in considerable numbers on the muddy sand-zone covered with *Zostera marina* at Tannowa during the months from February to June. Spawning occurs in the same season, but especially frequently in the period from March to April when the water temperature ranges from 13° to 16°C. Thus, only a single spawning season is seen in a year at Tannowa, although two spawning seasons were found in Tokyo Bay, respectively in the

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1) Contributions from the Seto Marine Biological Laboratory, No. 362.
2) A part of the studies supported by the financial aid granted from the Ministry of Education.

Publ. Seto Mar. Biol. Lab., IX (1), 1961. (Article 6)

months from April to June and the period from September to December (HAMADA and INO, 1957). The stomach content consists chiefly of a great many shells of *Decorifer matusimana* (Cephalaspidea, Opisthobranchia) and those of small bivalve mollusks, sometimes even the cannibal habit is observed. HAMADA and INO (1957) state also that this animal feeds on small bivalves and snails.

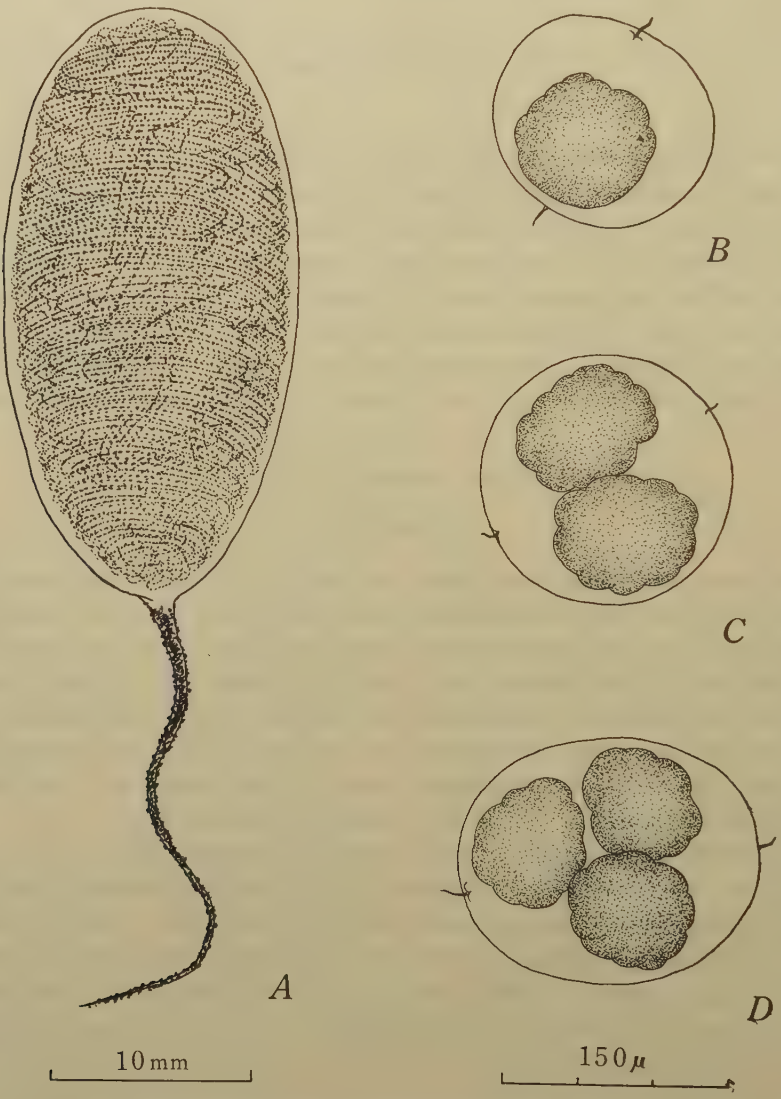

Fig. 1. *Philine japonica* LISCHKE.
A. Egg-mass.
B. Egg-capsule with one ovum.
C. Egg-capsule with two ova.
D. Egg-capsule with three ova.

The egg-mass (Fig. 1, A) is generally elongate oval in outline and varies from 25 to 60 mm in length and from 10 to 25 mm in diameter, with an average 35 mm in length and 15 mm in diameter. It is slightly brownish in colour and inserted in muddy sand with the proximal tail-like protuberance. The egg-capsules are provided each of a mucous string at each end and connected one another in a series, and the string of egg-capsules thus formed makes numerous regular coils within the clear gelatinous envelope. These features are almost the same as those of *Philine aperta* (GUIART 1901, TCHANG 1931, THORSON 1946) and *P. kinglipini* (TCHANG 1934). Each capsule contains 1 to 3 ova (Fig. 1, B–D). The diameter of egg-capsules varies from 130 to 200 μ and that of ova ranges from 83 to 86 μ.

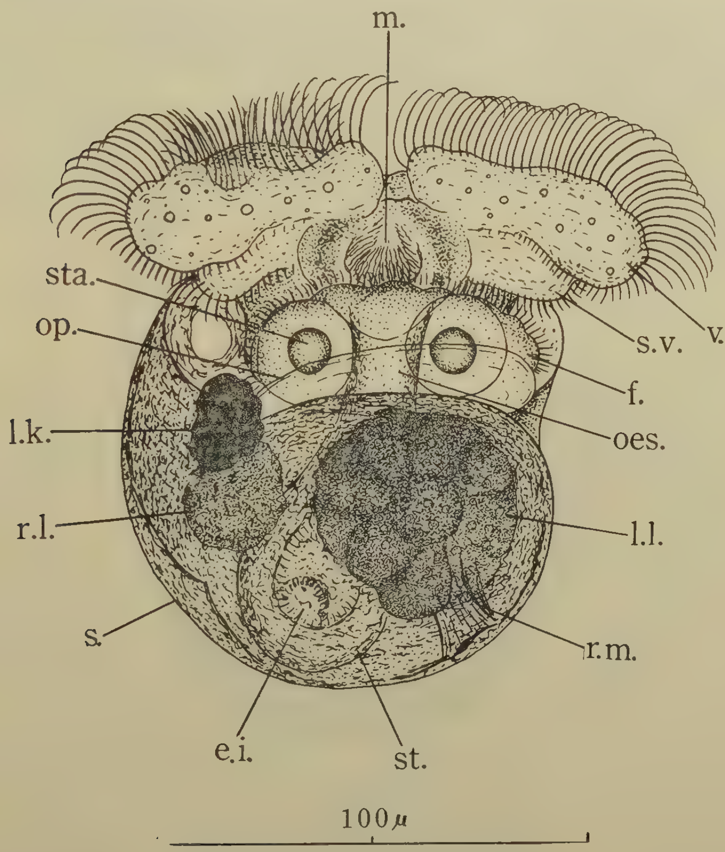

Fig. 2. *Philine japonica* LISCHKE.
Newly hatched veliger, from the ventral side.
Abbreviations: f.…foot, int.…intestine, l.k.…larval kidney, l.l.…left liver, m…mouth, oes.…oesophagus, e.i.…entrance to the intestine, op.…operculum, r.b.…rod-like bodies, r.l.…right liver, r.m.…retractor muscle, s.…shell, st.…stomach, sta.…statocyst, s.v.…sub-velum, v.…velum.

Early development: The egg-mass was kept in a glass-vessel at the room temperature of 5°–21°C. Embryos reached the earliest stage of veliger on the tenth day, in this stage they are marked on the right side with the larval kidney slightly pigmented in purplish red. This pigmentation of the larval kidney becomes gradually heavy with development, till it looks jet-black. The hatching out of veligers began on the thirteenth day and continued for three days.

Veligers: Newly hatched veligers (Fig. 2) are nearly roundish in shape and 130 by 150 μ in size on an average. Shell (Fig. 3) is sinistral, roundish ovoid in shape and 110 to 135 μ in long diameter. It is colourless, but furnished densely with very fine papillose sculptures. Therefore it is somewhat difficult to observe the visceral organs from the outside of shell. The aperture is very large, occupying more than a half of the whole frontal projection of the shell and with the columellar edge nearly straight. Unfortunately the operculum was not observed by the present author, although Tanaka (1958) mentions it is "paucispiral" and his figure shows a semicircular outline and 2½ coils. The bilobed velum is unpigmented and contains several refracting granules. The subvelum is present. There are no eyes as in larvae of other Philinids (Thorson 1946), although statocysts are well marked. The foot is ciliated with numerous short cilia all

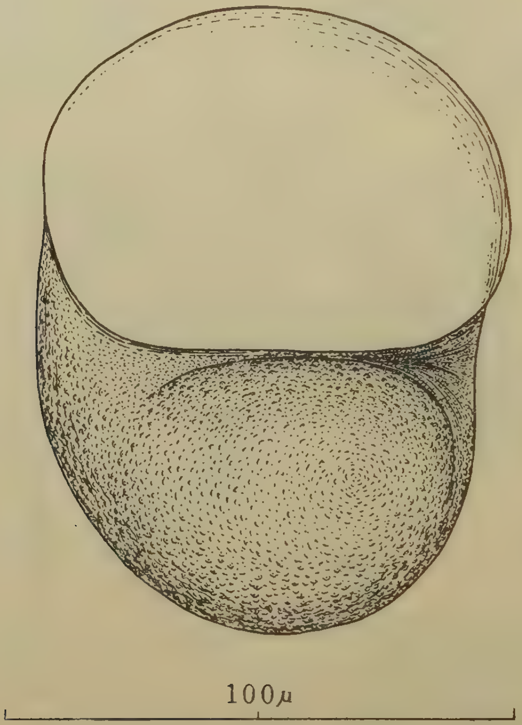

Fig. 3. *Philine japonica* Lischke.
Larval shell, from the ventral side.

over the surface and tapers off at the end in a pointed shape. The mouth is rather large and unpigmented. The broad oesophagus leads straight to the stomach. There are some so-called "rod-like bodies" seen in the wall of the right side of stomach (see Fig. 5 B of *Doridium gigliolii*) just as in the case of *Archidoris pseudoargus* mentioned by THOMPSON (1959). There are two liver-lobes, they are opaque and slightly brownish yellow in colour. The left lobe is much larger than the right; both lobes are devoid of any refracting granules in the tissue. This latter feature differs distinctly from that of *Doridium gigliolii* belonging to the same family and described next. Sometimes black pigments are seen on the surface of the left liver lobe. The intestine starts from the dorso-posterior part of stomach and probably leads straight to the anus, so it can not be seen from the ventral side. A large jet-black larval kidney is found on the right side of the body as already described by HAMADA and INO (1957) and TANAKA (1958); this is a well known feature in Philinids as mentioned by THORSON (1946).

Doridium gigliolii (TAPPARONE-CANEFRI)

(Figs. 4–6)

This species appears also in considerable numbers and spawns in the muddy sand-zone at Tannowa during the same season as that mentioned in the case of the preceding *Philine japonica*. Sometimes many empty shells of *Decorifer matusimana* were found in feces, probably the feeding habit of this species is quite the same as that of *P. japonica*. The structure of the egg-mass of this species is similar to the general type found in the genus *Philine*. Unlike that of *P. japonica*, however, the egg-mass (Fig. 4, A) of this species is very slender and milky white in colour. An egg-filament is enclosed within the clear gelatinous envelope in spiral coils, although they are not so regular as in *P. japonica*. The egg-mass is also anchored to the bottom by inserting a tail-like protuberance issued from the proximal end into the muddy sand. The shape of the egg-mass and the somewhat irregular arrangement of egg-filament are very similar to those of *Doridium carnosum* and *D. depictum*, var. *minor* described by TCHANG (1931 and 1934). The egg-mass varies from 20 to 53 mm in length and 6 to 18 mm in diameter, with an average 30 mm in length and 10 mm in diameter. The number of ova within the egg-capsule varies according to mass, from 1 to 2 (rarely 3) in some masses or 3 to 4 (rarely 1 or 5) in others (Fig. 4, B–D). TCHANG (1931) states "La nombre d'oeufs que contient une coque est de 3 à 4 ou de 7 à 11, suivant la ponte" as to *D. carnosum*. An animal collected at Tannowa on March 2, 1960 and brought to the laboratory was found spawning in the afternoon of March 10 when the water temperature was 19°C. The spawn was 20 mm in length and 7 mm in diameter. In this egg-mass, only a single ovum was contained in each egg-capsule. The diameter of these egg-capsules was 150 μ on an average and that of ova was about 85 μ.

Early development: The above-mentioned egg-mass was kept at the room temperature of 10°–22°C. It was on the third day of the development that embryos reached the gastrula stage; at this stage the embryos are triangular in shape. The rotatory motion of embryos of the trochophore stage in the capsule commenced on the forth day, and the embryos passed into the earliest stage of

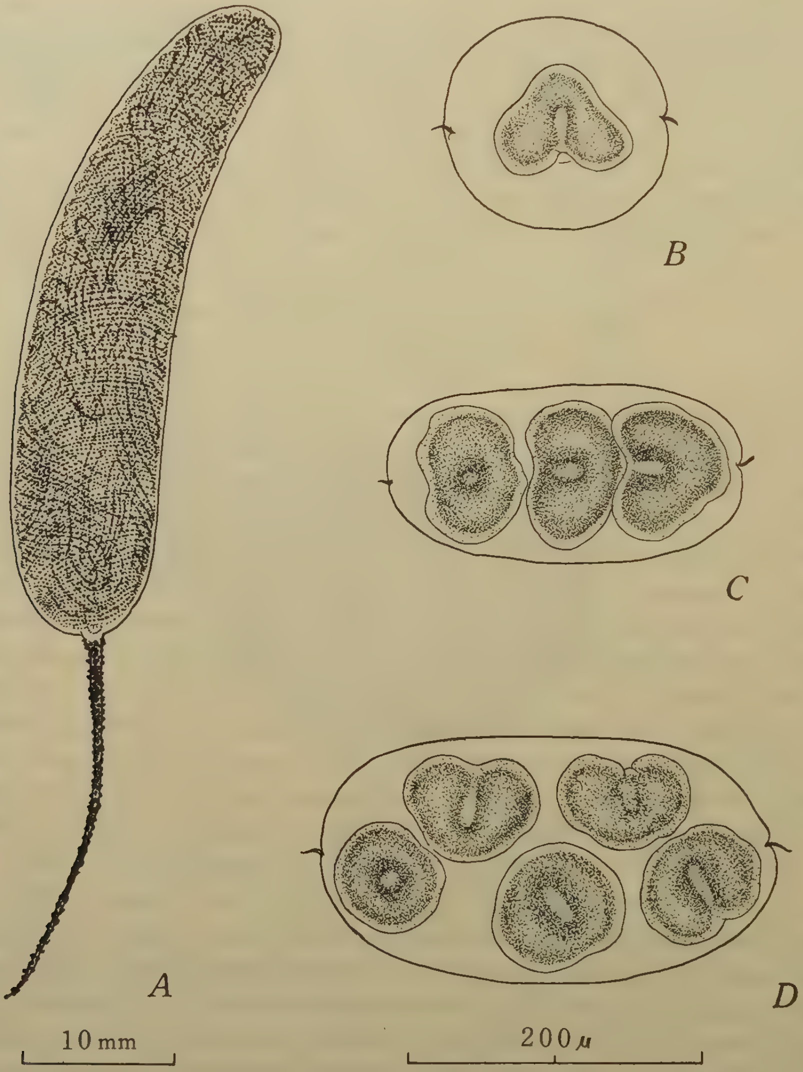

Fig. 4. ***Doridium gigliolii*** (TAPPARONE-CANEFRI).
A. Egg-mass.
B. Egg-copsule with one ovum.
C. Egg-capsule with three ova.
D. Egg-capsule with five ova.

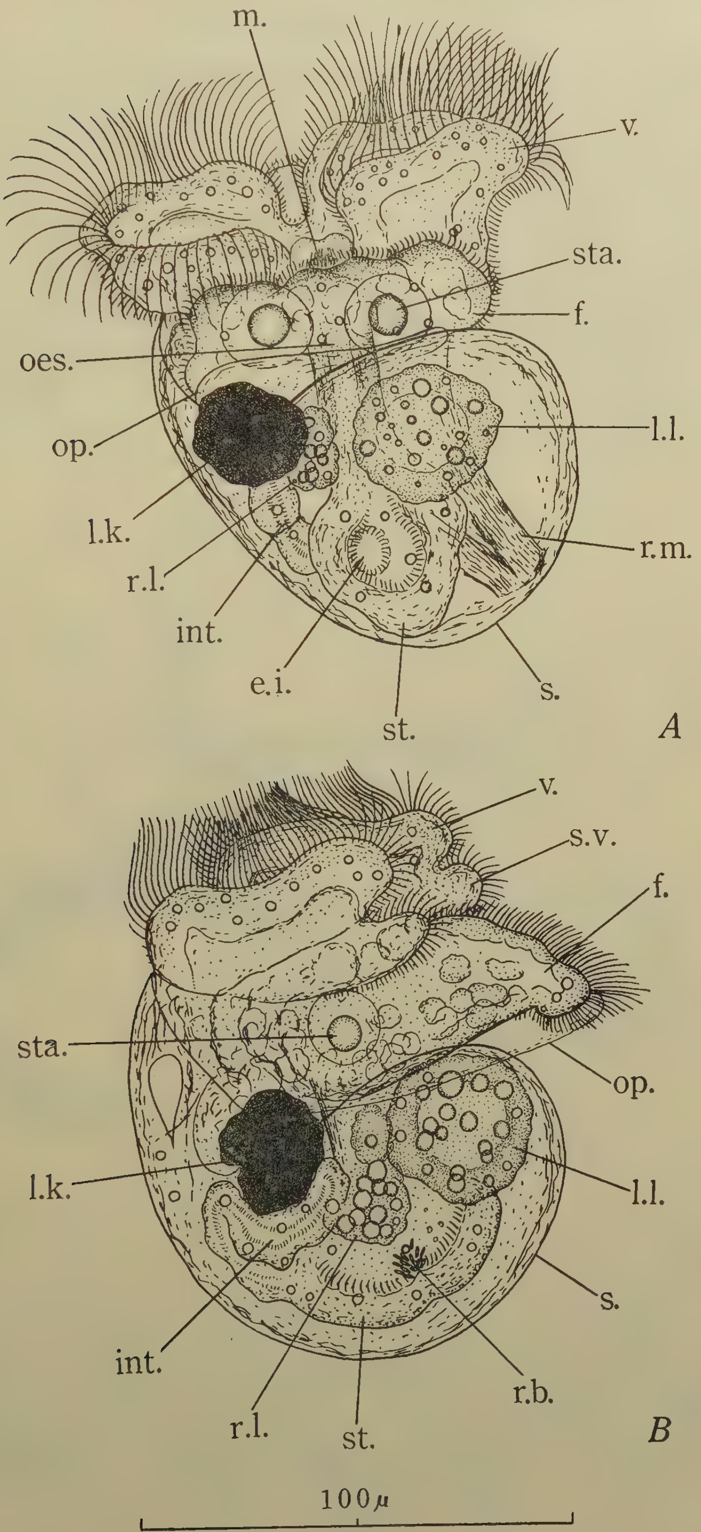
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Fig. 5. *Doridium gigliolii* (TAPPARONE-CANEFRI).
A. Newly hatched veliger, from the ventral side.
B. The same, from the right side.
(For abbreviations see Fig. 2.)

veliger on the sixth day. On the tenth day the embryos attained the nearly completed veliger stage and on the next day the hatching out of larvae from the egg-mass was observed and it continued all the twelfth day.

Veligers: The structure of the newly hatched veligers (Fig. 5, A–B) are nearly the same as those of the preceding species *P. japonica*. The body is about 135 μ in length on an average. The larva is quite colourless exclusive of the liver lobes and a large jet-black larval kidney on the right side of the body. This pigmentation of the larval kidney agrees with that commonly found in forms of the genus *Philine*. The shell of the newly hatched veliger (Fig. 6) is sinistral, transparent, colourless and sculptured with very minute dots densely set. The shell ranges from 110 to 200 μ in long diameter and with an average of 140 μ, and it is not so rounded as in *P. japonica*. The aperture is large, 85 to 102 μ in the diameter and with an average of 94 μ, it occupies about half of the whole frontal projection of the shell. The operculum is circular and has a spiral line coiling about 1¾ times. Subvelum is present; the velum and often the subvelum, too, have several refracting granules in the tissue. Statocysts are present, but the eyes are not formed in this species, either. The foot is ciliated and the end tapers off in a triangular shape just as in the preceding species; this feature

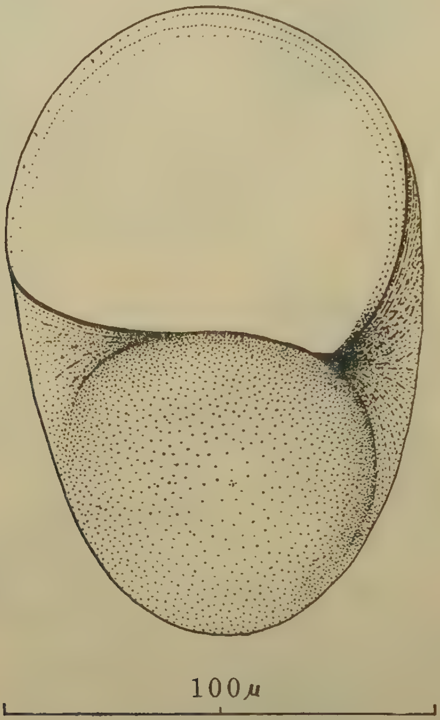

Fig. 6. *Doridium gigliolii* (TAPPARONE-CANEFRI).
Larval shell, from the ventral side.

seems to be a characteristic common to these species. The mouth is ciliated and unpigmented, and the oesophagus is rather stout. The stomach contains some refracting granules in the wall, but not pigmented. So-called "rod-like bodies" are seen distinctry on the right side of stomach; but the area containing these bodies is rather smaller than in *P. japonica.* Two liver lobes are present, the left lobe is larger, as usual, than the right which is comparatively smaller than that of *P. japonica.* Both lobes are translucent, yellowish brown in colour, and contain very large refracting granules in their walls; this aspect is a character unique to the veliger of this species differentiating it distinctly from that of the preceding species *P. japonica.* The intestine is long and assumes a S-shaped course when it is seen from the right side. It has some refracting granules in the wall.

Goniodoris sugashimae BABA

(Figs. 7–10)

A single specimen of this species was collected from the under surface of a stone near the low water mark at Kada on April 26, 1960, and an egg-mass was found near by. This specimen laid an egg-mass on the bottom of a glass-vessel when it was brought in the laboratory on the same day. This egg-mass (Fig. 7, A) was quite the same as that found in the natural environment. It resembles somewhat that of *Goniodoris castanea* (BABA, HAMATANI and HISAI, 1956): it is milky white in colour and consists of a 20 mm long ribbon which is 3 mm broad and attached to the substratum by an edge along its whole length and forms an incomplete circle with a 7 mm diameter. A single ovum, 119 μ in diameter in an examined sample, is contained in each elliptical egg-capsule (Fig. 7, B) whose diameters are respectively 145 and 155 μ, for example.

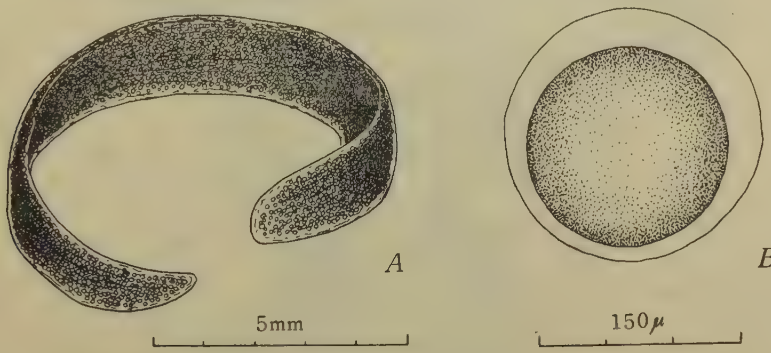

Fig. 7. *Goniodoris sugashimae* BABA.
A. Egg-mass.
B. Ovum in the capsule.

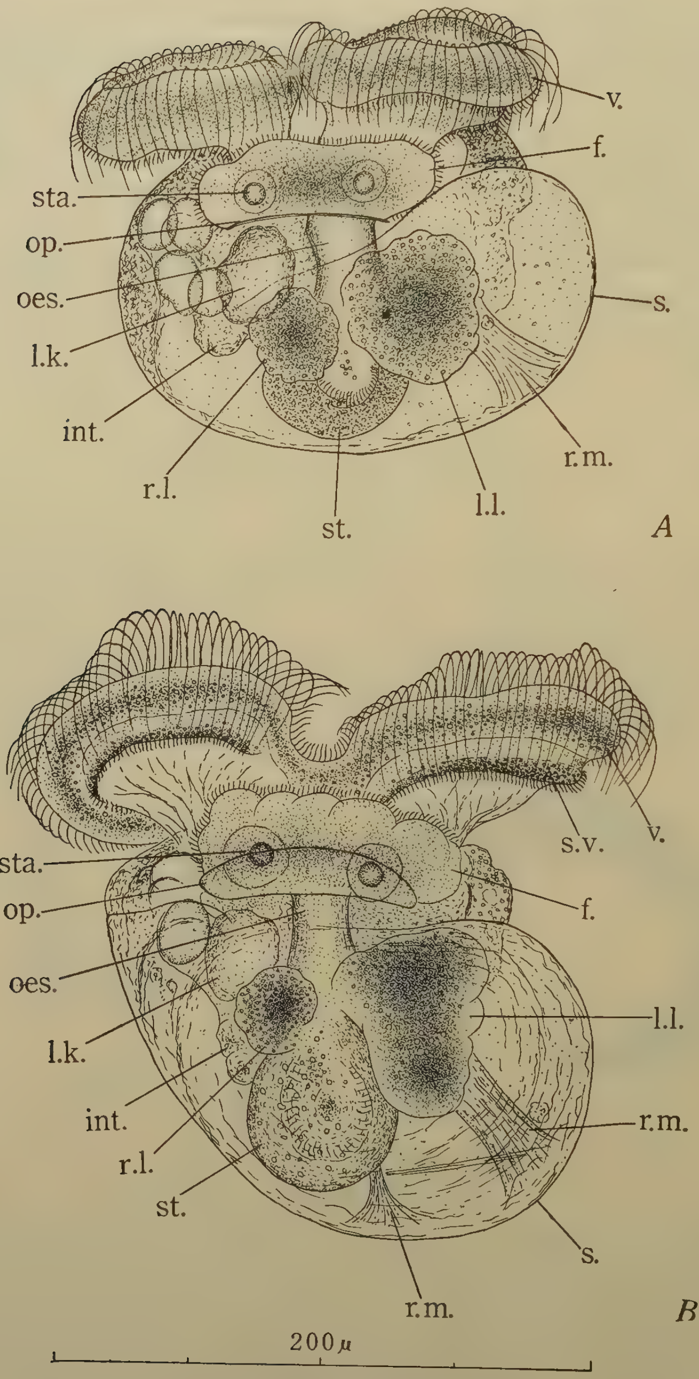
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Fig. 8. *Goniodoris sugashimae* BABA.
A. Intra-capsular veliger 6 days old, from the ventral side.
B. Intra-capsular veliger 7 days old, from the ventral side.
(For abbreviations see Fig. 2.)

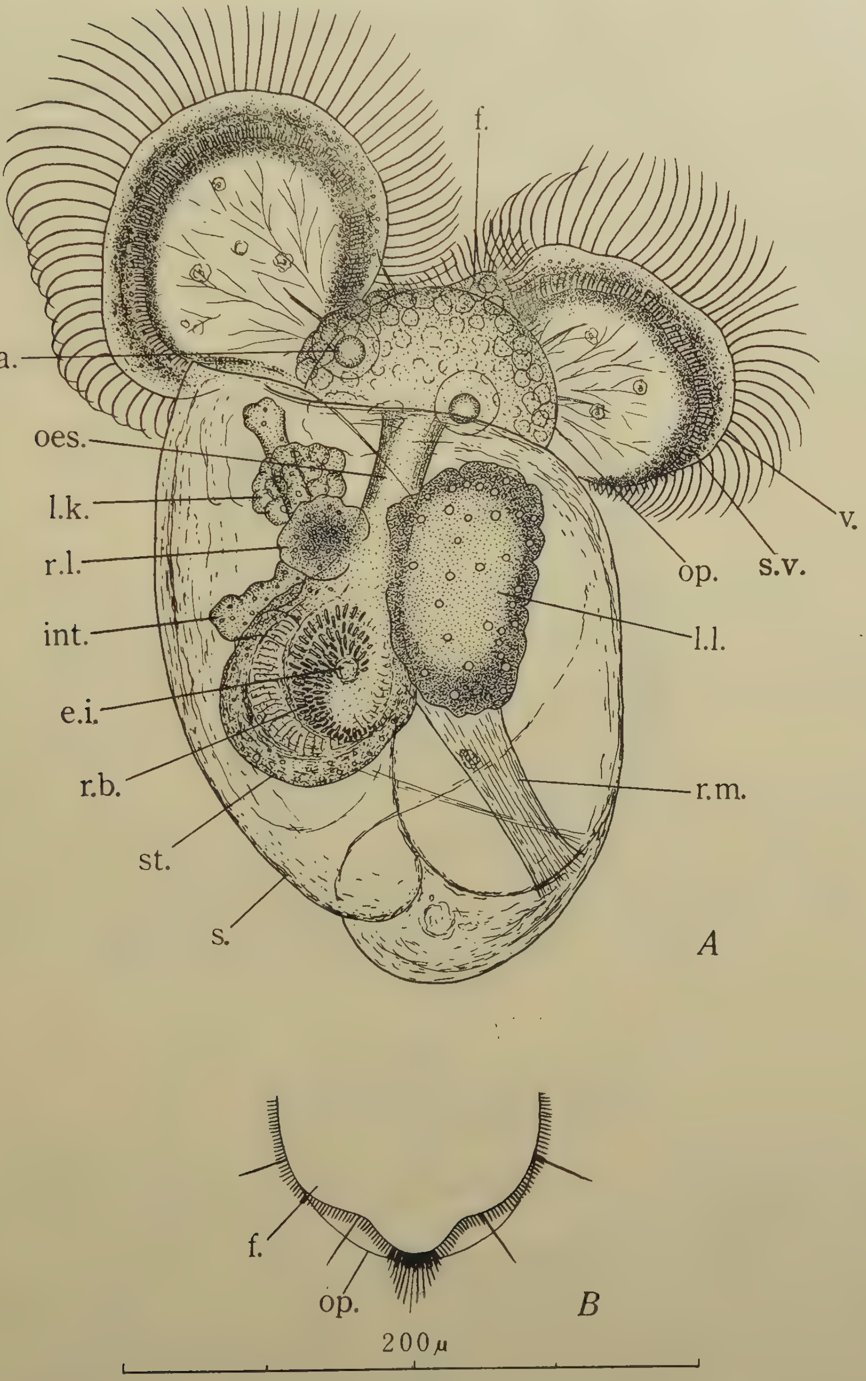
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Fig. 9. *Goniodoris sugashimae* BABA.
A. Newly hatched veliger, from the ventral side.
B. Foot and operculum, showing the sensory cilia.
(For abbreviations see Fig. 2.)

Early development: On the fourth day all the embryos had already developed to a veliger-like shape. On the sixth day, the intra-capsular veligers (Fig. 8, A) attained 170 μ antero-posteriorly, the shell assumed an antero-posteriorly compressed form and with sculptures consisting of very minute dots, and the formation of organs was nearly completed. On the seventh day the veligers (Fig. 8, B) had grown to be about 230 μ antero-posteriorly and distinctly was provided with the subvelum. On the next day the first hatching out was observed and this continued for two days. During the observations the room temperature fluctuated from 15° to 25°C.

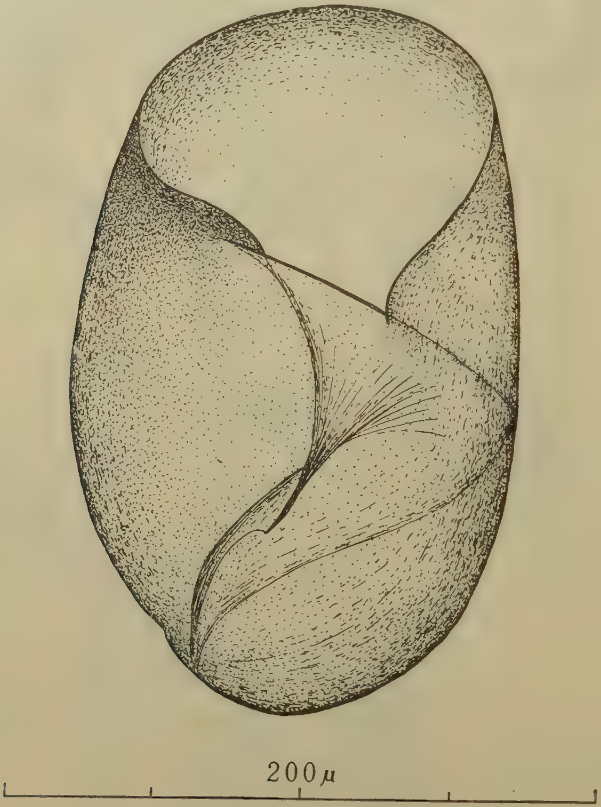

Fig. 10. *Goniodoris sugashimae* Baba.
Larval shell, from the ventral side.

Veligers: The newly hatched veligers (Fig. 9, A) is very peculiar in form. The whole body is somewhat elongate, rather large, 300 μ in antero-posterior diameter for instance, transparent and quite colourless. The structure of shell (Fig. 10) is quite unique, it is well developed, elongate ovoid in shape, 230 μ in long diameter on an average, and with a sinistro-spiral columella. The operculum is circular and with a spiral line. The subvelum is present, both the velum and subvelum are devoid of any refracting granules. The statocysts are distinct and statolith looks somewhat lighter than in other species; eyes absent. The foot is covered with numerous short cilia all over the surface. Some long sensory cilia (Fig. 9, B) are issued from the periphery of the foot, four of which are arranged two on each side and other several ones at the tip. The foot contains many large cells in the tissue. The tip is tapering, but it does not protrude beyond the operculum edge. The stomach is characterized in having a broad zone of "rod-like bodies" which can be seen very distinctly from the ventral side. There are two liver lobes: the right lobe is smaller than the left, connected with the right side of the entrance to the stomach and contains several very minute refracting granules, while the left one is very large, connected with the left side of the entrance to the stomach and contains some refracting granules larger than those of the right lobe. The intestine is slender and the larval kidney is colourless.

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POLYCHAETOUS ANNELIDS COLLECTED OFF THE WEST COAST OF KAMCHATKA

I. NOTES ON SPECIES FOUND IN THE COLLECTION OF 1957-58[1]

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With 14 Text-figures and 1 Table

The following accounts of the polychaetous annelids are based upon a collection made by dredging at 66 to 125 m deep stations off the west coast of Kamchatka during the ecological survey of the king crab, *Paralithodes camtschatica* (Tilesius), carried out by members of the Hokkaidô Regional Fisheries Research Laboratory in the years 1957–58. The positions of the stations are shown in Table 1 and Text-figure 1. The collection comprises the following 19 species belonging to ten families, most of which are the species found commonly in the circumpolar regions.

Family Polynoidae
  1. *Harmothoë extenuata* (Grube)
  2. *Arcteobia* sp.
  3. *Gattyana ciliata* Moore
  4. *Eunoë spinicirris* Annenkova

Family Nereidae
  5. *Nereis pelagica* Linnaeus

Family Nephtyidae
  6. *Nephtys longosetosa* Oersted
  7. *Nephtys caeca* (Fabricius)
  8. *Nephtys punctata* Hartman
  9. *Nephtys discors* Ehlers
  10. *Nephtys ciliata* (Müller)

Family Opheliidae
  11. *Travisia brevis* Moore

Family Maldanidae
  12. *Praxillella gracilis orientalis* Zachs
  13. *Axiothella* sp.

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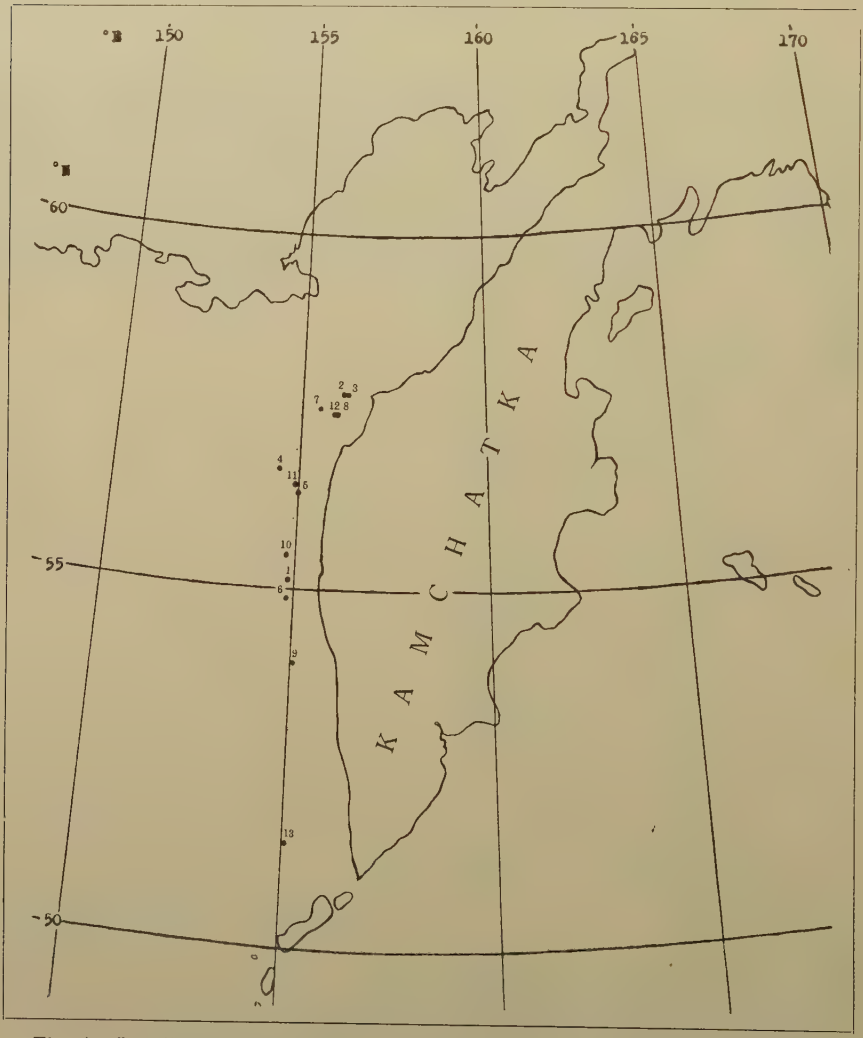
[1] Contribution No. 5 from the Shirikishinai Marine Station for Biological Instruction, Hokkaido Gakugei University.

Family Owenidae
    14. *Owenia fusiformis* Delle Chiaje
Family Sternaspidae
    15. *Sternaspis scutata* (Ranzani)
Family Ampharetidae
    16. *Amphicteis scaphobranchiata* Moore
Family Terebellidae
    17. *Terebellides stroemi* Sars
Family Sabellidae
    18. *Potamilla neglecta* (Sars)
    19. *Chone infundibuliformis* Kröyer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KAMCHATKA
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Fig. 1. Locality map of Kamchatka. Numerals indicate the stations at which polychaetes were found.

Table 1. List of station and date of collection.

No. of Station	Date of collection	Station	Depth in m
1	Jun. 10, 1957	55°10′N., 154°49′E.	100
2	Jun. 24, 1957	57°52′N., 156°24′E.	97
3	Jun. 24, 1957	57°52′N., 156°26′E.	97
4	Jun. 29, 1957	56°42′N., 154°22′E.	122
5	Jun. 29, 1957	56°22′N., 155°00′E.	93
6	Jul. 4, 1957	54°50′N., 154°49′E.	92
7	Jul. 11, 1957	57°36′N., 155°34′E.	117
8	Aug. 8, 1957	57°32′N., 156°10′E.	66
9	May 28, 1958	54°00′N., 155°05′E.	95
10	May 31, 1958	55°30′N., 154°43′E.	125
11	Jun. 2, 1958	56°30′N., 154°57′E.	85
12	Jun. 15, 1958 Jul. 27, 1958	57°30′N., 156°10′E.	70
13	Jul. 15, 1958	51°30′N., 156°05′E.	105

Before proceeding further, I wish to tender my sincere thanks to Dr. Toraichiro KINOSHITA and Mr. Isamu TAKEUCHI of the Hokkaido Regional Fisheries Research Laboratory for their kindness in placing the material at my disposal, and my cordial thanks are due to Prof. Tohru UCHIDA, Hokkaido University, and Dr. Olga HARTMAN, Allan Hancock Foundation of the University of Southern California, for their various helpful suggestions and also to Dr. Marian H. PETTIBONE of the University of New Hampshire for her kindness in sending me copies of her papers indispensable for this work. I am deeply indebted to Prof. Hideji YAMAGUCHI, Hokkaido Gakugei University, for his kind guidance and for his kindness in reading the manuscript.

Description of the Species

Family POLYNOIDAE

Harmothoë extenuata (GRUBE)

Harmothoë propinqua: DITLEVSEN, 1917, p. 14, pl. 3, figs. 1, 3.
Lagisca extenuata: FAUVEL, 1923, p.76, fig. 28; WESENBERG-LUND, 1950, p. 8.
Harmothoë extenuata: PETTIBONE, 1953, p. 31; ——, 1954, p. 222.

Occurrence: St. 7.

The body measures 18 mm in length for 35 setigerous segments and some regenerating segments in the caudal region, and 6 mm width including parapodia at the middle region. The length of the prostomium is shorter than its basal width, both the lateral margins bulge prominently at the middle portion and there is a well defined peak at each side. It has two pairs of well developed eyes, the anterior ones being about twice the posterior in size. Elytra in 15 pairs are arranged as usual in the genus. They are reniform, membranous and fairly adherent. Most of the surface of the elytra is covered by tubercles with sharp curved tips or bifid tips, but along the anterior border it is entirely free from spines. In addition to the tubercles, there are soft globular or ellipsoid papillae, narrowing basally and arranged in series at some intervals, in the surface near the posterior margin and other parts of the elytra. The posterior and lateral margins are fringed with other slender papillae. The notopodial setae are unidentate and distally serrated. The neuropodial setae are bifid. Nephridial papillae begin to occur on the 8th parapodium. The allied species *H. multisetosa* differs from this species in the tubercles of elytron.

Arcteobia sp.

Occurrence: St. 11.

A single incomplete specimen, which had lost the head and all elytra, was collected. It measures 18 mm for 35 setigerous segments. Elytrophore are found in segments 2, 4, 5, 7---23, 26, 29, 32. The notopodial setae of one form are finer and provided with a very long capillary tip, and the other is short, slightly curved and denticulate. The neuropodial setae consist of a few long, slender setae with capillary tip born on the superior region of the neuropod and numerous stouter bidentate setae on the inferior region. Though the prostomium and the elytra were not examined, it was attributed to this genus from the elytrophore number and features of the notopodial and neuropodial setae.

Gattyana ciliata MOORE

Gattyana ciliata: ANNENKOVA, 1937, p. 148, pl. II, fig. 9, pl. IV, fig. 33; BERKELEY and BERKELEY, 1948, p. 12, fig. II; PETTIBONE, 1953, p. 40, pl. 19, figs. 164–173.

Occurrence: St. 12.

An incomplete specimen was examined, which has lost the caudal portion and all elytra. The long palpi is covered with numerous small filiform papillae. The lobes of the prostomium have faint peaks. The anterior eyes are more dominant than the posterior eyes. There are found elytrophores of 11 pairs that present 2, 4, 5, 7---19, 21. Notopodial setae are very numerous, delicate, and have very long hair-like tipe. Neuropodial setae with rows of pectinae are simply a little curved. Though I could not examine elytra because of the damage to the specimen, it is identical with the present species from features of the notopodial setae and the ventral insertion of the lateral antennae.

Eunoë spinicirris ANNENKOVA

(Text-fig. 2, a–g)

Eunoë spinicirris: ANNENKOVA, 1937, p. 150, pl. I, fig. 7, pl. II, fig. 2, pl. III, fig. 24, pl. IV, figs. 31, 32.

Occurrence: St. 3.

Two complete specimens and two anterior body fragments were observed. The largest specimen with 38 setigerous segments measures 67 mm by 27 mm including parapodia. The prostomium (Fig. 2 a) is about 2 times broader than its length. The length of the median tentacle is approximately twice that of the lateral tentacle. The palps are stout, and nearly 2.5 times as long as the lateral tentacle. The entire surface of the palpi is densely beset with triangular papillae arranged in six longitudinal rows. The tentacular cirri are slightly shorter than the median tentacle. The surface of the median tentacle and the tentacular cirri has sparsely a few shorter papillae. The two pairs of well developed eyes are situated far back on the prostomium. The elytra are firmly attached, covering the dorsum but leaving the mid-dorsal line of the anterior exposed, and are attached to segments 2, 4, 5, 7---23, 26, 29, 32. On the surface of the elytra (Fig. 2 b) very large conical horn-like tubercles are sparsely scattered in the posterior margin and furnish closely uni- or bidentate small tubercles at the anterior margin, which is usually covered by the just anterior elytron. Their margin has no fringe. The parapodium (Fig. 2 c), well developed and elongated, is divided into two unequal rami. Dorsal cirri are covered with sparse unidentate papillae. The notopodial setae are arranged in 3 transverse rows, of which the first row consist of simple setae with a sharp end (Fig. 2 d). In the second and third rows there are two kinds of setae; one of them (Fig. 2 f) is very long, stout, straight having minute serrations on the whole exposed length, and is provided with a truncate tip with a very small middle projection, the other one (Fig. 2 e) is slightly curved, shorter and finer than the former. Though the notopodial setae of *E. Hozawai* OKUDA closely resemble those of this species, it is clearly distinguishable by lacking the small projection. The neuropodial setae (Fig. 2 g) are unidentate. The first pair of nephridial papillae begins on the 6th segment. The species was first recorded by ANNENKOVA from the north Japan Sea and Bering Sea. The present specimens are more or less different in having the elytra with a few conical tubercles at the posterior margin, but in other respects, they agree with ANNENKOVA's description.

Family NEREIDAE

Nereis pelagica LINNAEUS

Nereis pelagica: IZUKA, 1912, p. 154, pl. 17, figs. 1–6; FAUVEL, 1923, p. 336, fig. 130, a-f; OKUDA, 1939, p. 230.

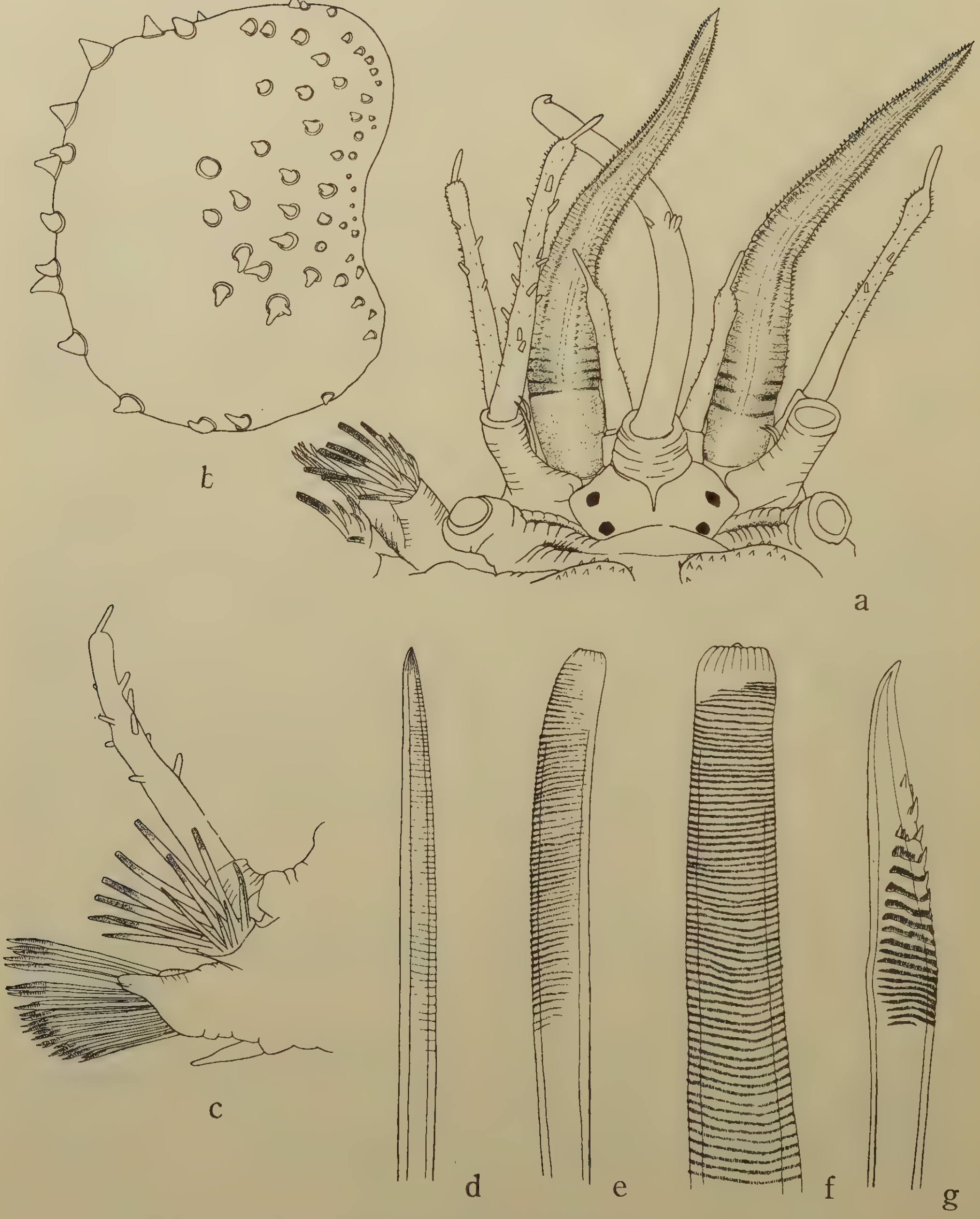

Fig. 2. *Eunoë spinicirris* ANNENKOVA.
a, Dorsal view of anterior portion, omitted on the right parapodium; *b*, 6th elytron; *c*, 7th parapodium; *d*, *f*, Notopodial setae; *a–c*, ca. ×32; *d–g*, ca. ×260.

Occurrence: St. 2, 1 specimen; St. 3, 1 spec.; St. 8, 1 spec.

Three specimens, of which the largest one with 74 chaetigers measures 113 mm by 10 mm at the widest part excluding parapodia. The arrangement of the paragnathi in the proboscies is as follows: I, 3 in a line; II, 12–14 in 2 oblique rows; III, 10–12 in a cluster; IV, 20–24 in a rough cluster of 3 rows; V, absent; VI, 4–5; VII–VIII, in several transverse rows, of which paragnathi of the anterior row are larger in size than those of the posterior rows. In the 1st and 2nd parapodia they are lacking inferior ligule of notopodium and notosetae. The first parapodium is comparatively large in size. The dorsal inferior ligules of the posterior parapodium from the 7th chaetiger are slightly longer than that of the other ones. The notopodial setae are all homogomph spinigers which are replaced by homogomph falcigers in the 26th–32th parapodium. Every homogomph falciger bears a bluntly rod-shaped apex, and is without teeth. In the superior division of the neuropodium there occur homogomph spinigers and heterogomph falcigers, and in the inferior division there are heterogomph falcigers and heterogomph spinigers.

Family NEPHTYIDAE

Nephtys longosetosa OERSTED

(Text-fig. 3)

Nephthys longosetosa: FAUVEL, 1923, p. 367, fig. 143, f–h; BERKELEY and BERKELEY, 1942, p. 193; ——, 1948, p. 52, fig. 76.
Nephtys longosetosa: PETTIBONE, 1954, p. 268, fig. 30, 1.

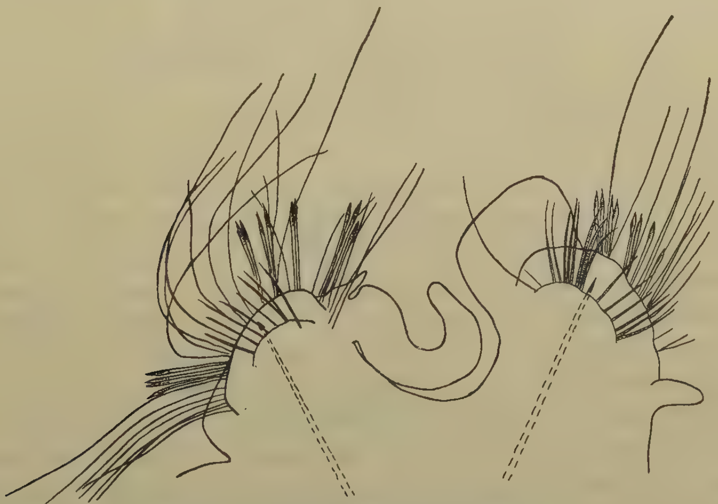

Fig. 3. *Nephtys longosetosa* OERSTED.
40th parapodium, anterior view. ca. ×33.

Occurrence: St. 1.

Two specimens were examined, of which the larger one measures 65 mm by 5 mm for 77 setigerous segments and the other 58 mm by 4 mm. The proboscis is furnished with 22 rows of papillae, 3 or 4 in each row. There is a long median papilla. Acicular lobes of the parapodium (Fig. 3) are round and have no incision in the median region. Neuropodial postsetal lamella is much longer than the notopodial one which bears two unequal lobes. The dorsal cirri are scanty. The branchiae are present first from the 3rd setigerous segment are rather large, sickle-shaped, and continue almost to the posterior end.

Nephtys caeca (FABRICIUS)

(Text-fig. 4)

Nephthys caeca: FAUVEL, p. 365, fig. 142, a–l; OKUDA, 1938, p. 123; OKUDA and YAMADA, 1954, p. 186, fig. 4.
Nephtys caeca: HARTMAN, 1950, p. 95.

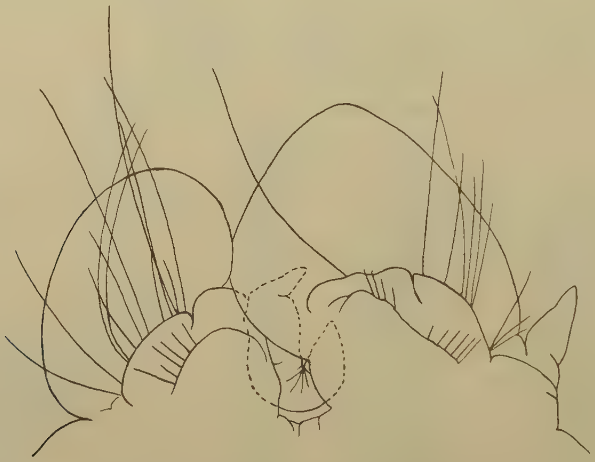

Fig. 4. *Nephtys caeca* (FABRICIUS).
30th left parapodium, anterior view. ca. ×20.

Occurrence: St. 7.

A complete specimen measures 118 mm for 120 setigerous segments and by 9 mm. including parapodia. The proboscis was not everted, therefore, papillae with 22 longitudinal rows were examined by dissection. There is no median papilla. The branchiae are present, begining first on the 4th setigerous segment. Both dorsal and ventral rami of the parapodium are separately located with some distance between them in the anterior part neuropodial postsetal lamella of the anterior region is more or less triangular and foliaceous, and that of the notopodium is oval. Acicular lobes of both notopodia and neuropodia are distinctly divided into two lobes by a deep incision. The features of the parapodium (Fig. 4) agree well with FAUVEL's figures.

Nephtys punctata HARTMAN

(Text-fig. 5)

Nephtys punctata: HARTMAN, 1938, p. 155, fig. 67; ——, 1950, p. 96.

Occurrence: St. 5, 1 spec.; St. 11, 1 spec.

A simple fragment of an animal obtained from St. 5, which has lost the posterior end, measures 55 mm long for 70 setigerous segments. Proboscis is provided with 22 rows of papillae and a long median dorsal papilla, and it is covered with minute prickly cones. Branchiae first appear on the 7th setiger and are present as far as the posterior end of the fragment. They are sickle-shaped cirrus. In both parapodia (Fig. 5) acicular lobes are equally bilobed. The neuropodial postsetal lamellae are elongate as far as 50th setiger. Although this specimen agrees well with HARTMAN's species in many characteristics, it differs in the starting of the branchiae; in this specimen it begins on the 7th setiger, whilst in those of HARTMAN's specimen it begins on the 8th or 9th setiger.

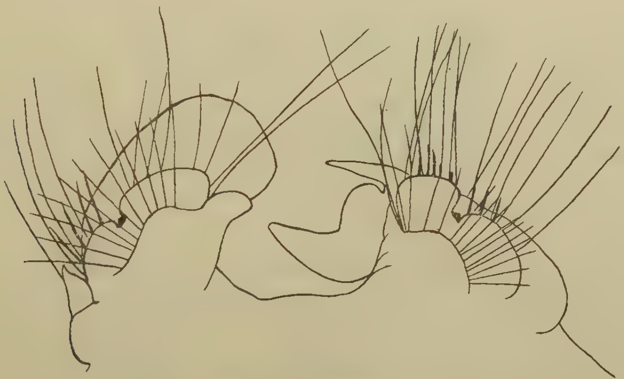

Fig. 5. *Nephtys punctata* HARTMAN.
50th parapodium, anterior view. ca. ×25.

Nephtys discors EHLERS

(Text-fig. 6, a–d)

Nephthys discors: EHLERS, 1868, p. 626, pl. 23, figs. 39, 40.
Nephtys rickettsi: HARTMAN, 1938, p. 153, fig. 66.
Nephtys discors: HARTMAN, 1950, p. 96; PETTIBONE, 1954, p. 270, fig. 30, m

Occurrence: St. 9.

Two specimens and one anterior fragment of an animal were collected. The longest specimen measures 235 mm and is composed of 127 setigerous segments. Dorsal prostomial antennae are about a half as large as ventral antennae. The everted proboscis bears 20 rows of bifid terminal papillae and a single papilla in the two specimens, and the fragment has 21 rows of similar papillae and a single papilla. The subterminal papillae are arranged in 22 longitudinal rows of 4 to 6 papillae. The branchiae begin on the 6th or 7th segment, and at the outset they are rather small, then increase in size on the following segments. They are coiled inwards and are inflated on the basal half at the middle region (Fig. 6 a). In the posterior half of the body they are thick and club-shape, and continue back to near the end of the body; a few of the last segments lack them (Fig. 6 c, d). In typical parapodia at the middle region the notopodial acicular lobe is incised in unequal bilobes, the neuropodial one is rounded. Postsetal lobes are broad and foliaceous; the notopodial one is much smaller in size than the neuropodial one (Fig. 6 b). In the posterior region noto- and neuropodial lobes are much rudimentary. The parapodium of the median region of these specimen well resembles those of PETTIBONE's figures.

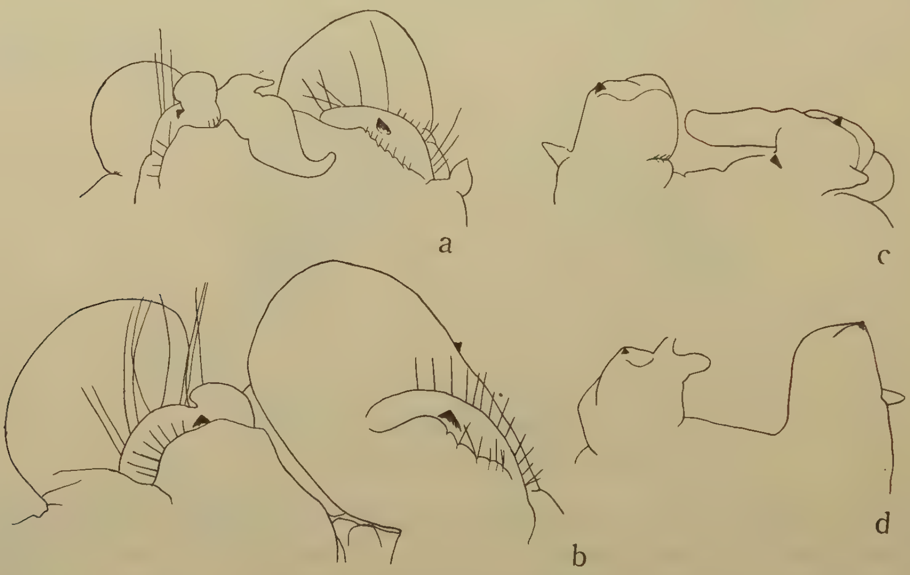

Fig. 6. *Nephtys discors* EHLERS.
a, 26th parapodium; *b*, 40th parapodium; *c*, Parapodium in posterior half of body; *d*, Posterior parapodium. All anterior view, ca. ×15.

Nephtys ciliata (MÜLLER)

Nephthys ciliata: FAUVEL, 1923, p. 371, fig. 145; BERKELEY and BERKELEY, 1948, p. 55.
Nephtys ciliata: PETTIBONE, 1954, p. 270, fig. 30, n.

Occurrence: St. 4, 1 spec.; St. 12, 1 spec.

Two anterior body fragments measure 68 mm (St. 4) and 110 mm (St. 12) in length respectively. The proximal surface of the proboscis is papillated, and there are 22 longitudinal rows of papillae and a long unpaired dorsal papilla. The branchiae, in the specimen from St. 4, are first present from the seventh setiger and in the specimen from St. 12 begin on 5th setiger, and are present as far as the posterior end of the fragment. Acicular lobes in both noto- and neuropodia are distinctly bilobed, and the neuropodial postsetal lobe is slightly larger in size than that of the notopodial one.

Family OPHELIIDAE

Travisia brevis MOORE

Travisia brevis: MOORE, 1923, p. 220; BERKELEY, 1929, p. 313; BERKELEY and BERKELEY, 1952, p. 90.

Occurrence: St. 4.

A single complete specimen measures 33 mm by 6 mm. There are twenty-nine segments. The body is elongated, grub-like, and is more pointed at the anterior end than the posterior. The surface of the body is covered with vesicles of various sizes. Branchiae, simple ciriform are present from the 3rd segment to the 24th. The ventral parapodial lappets from 15th segment to 25th segment are pointed and extend prominently at either side. These projections are not present on the last few segments which form a pre-anal tube. Notopodial and neuropodial setae are all slender and thread-like, and are present from the 2nd segment to the 25th. Pygidium consists of a ring of stout lobes.

Family MALDANIDAE

Praxillella gracilis orientalis ZACHS

(Text-fig 7, a–c)

Praxillella gracilis orientalis: ANNENKOVA, 1937, p. 182.

Occurrence: St. 13.

Three anterior body fragments were investigated, the largest one measuring 80 mm for 14 setigerous segments. The cephalic plate has a well developed rim, which has lateral and posterior notches, but the latter is very slight. The nuchal grooves are long, and are slightly bent outwards at both the anterior and posterior parts. Prostomium is extended into a finger-like projection. In the first three chaetigers there are reduced crotchets, which have no gular bristle and have only 3 teeth above the main frang (Fig. 7, a–b). There are 7–9 reduced crotchets in each neuropodium. In the 4th chaetiger there are 17 developed crotchets, the crown of which bears 5–6 long slender teeth, and it has some long gular bristles curved upwards over the beak (Fig. 7 c). Although the posterior end of these specimens could not be examined, I have attributed the present specimens to this subspecies, from the structure of the head and the number of reduced crotchets in the first three setigerous segment.

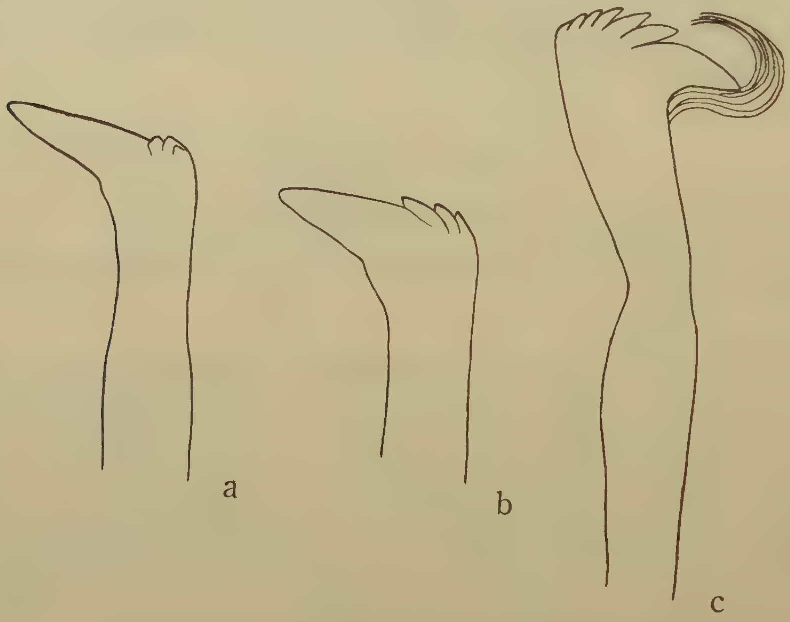

Fig. 7. *Praxillella gracilis orientalis* ZACHS.
a–b, Reduced crotchets from 2nd neuropod; *c*, Crotchet from 13th neuropod. ca. ×420.

Axiothella sp.

(Text-figs. 8 and 9, a–b)

Occurrence: St. 1, 1 spec.; St. 4, 1 spec.; St. 11, 2 spec.

The largest one of these four anterior fragments measures 70 mm for 15 setigerous segments. The cephalic plate is elongated antero-posteriorly, and the lateral margin possesses a well defined rim which has two deep notches at the sides and is perfectly smooth in the mid-dorsal line (Fig. 8). The anterior segments to the 7th are rather shorter than the succeeding segments whose length is about three times their width. The crotchets are present from the first setigerous segment, having 4–5 teeth above the main frang (Fig. 9 a). There is a row of 12–18 crotchets, and the number is greater in the following segments. The crotchets of the first four chaetigers have no gular bristles nor nodules. The crotchets with gular bristles are present first from the 5th chaetigers (Fig. 9 b). The dorsal bristles are slender and very thinly bordered by capillaries. Because the posterior region was missing these specimens could not be identified aculately, but judging from the presence of the crotchets in all setigerous segment and the absence of the acicular setae in the first three chaetigers they may belong to the present genus and it seems that the specimens are closely related to *A. catenata* (Malmgren) which has been reported by Wesenberg-Lund (1948) from the west coast of Greenland. *A. catenata* is

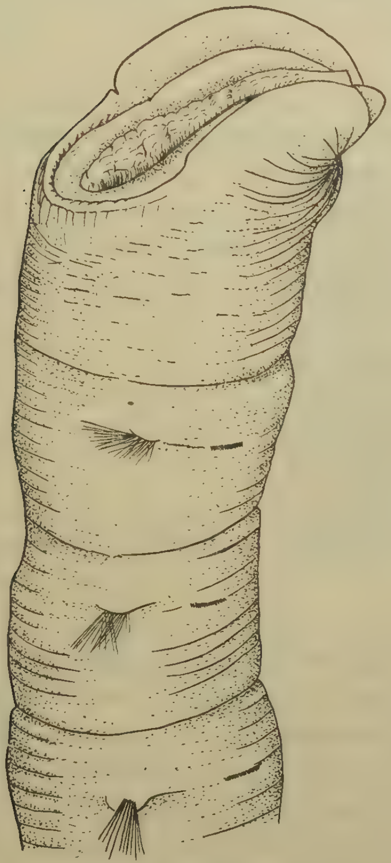

Fig. 8. *Axiothella* sp.
Lateral aspect of anterior part of body. ca. ×13.

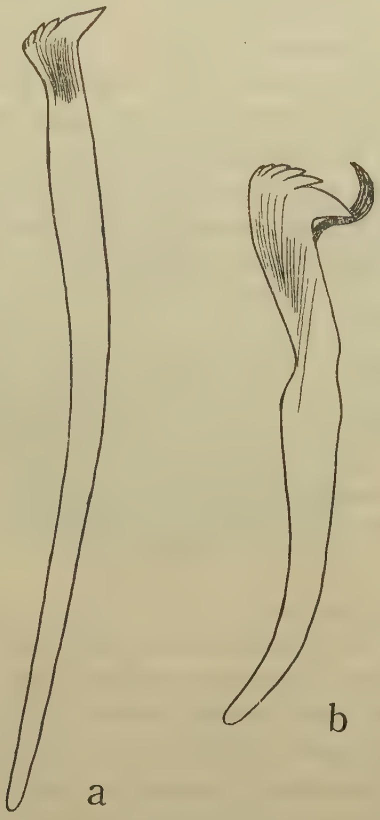

Fig. 9. *Axiothella* sp.
a, Crotchets from 1st neuropod;
b, Crotchets from 14th neuropod.
ca. ×260.

Arctic species, has also been recorded from Okhotsk Sea by ANNENKOVA (1937) and USCHAKOV (1955).

Family OWENIDAE

Owenia fusiformis DELLE CHIAJE

Owenia fusiformis: FAUVEL, 1927, p. 263, fig. 71, a–f; OKUDA, 1937, p. 252, fig. 27; WESENBERG-LUND, 1949, p. 345; USCHAKOV, 1955, p. 346, fig. 128.

Occurrence: St. 8.

A single anterior fragment with 7 setigerous segments was examined. The body is cylindrical and the prostomium is surmounted by a crown consisting of six membranous lobes branching at the terminal end. The dorsal setae are spinuous and are present from the first segment. There are no ventral uncini in the first three setigerous segments, and in the succeeding segments they have bidentates with elongated manubria arranged in transversal rows. Tube unknown.

Family STERNASPIDAE

Sternaspis scutata (RANZANI)

(Text-fig. 10, a–c)

Sternaspis costata: MARENZELLER, 1879, p. 34, pl. 6, fig. 4.
Sternaspis scutata: FAUVEL, 1927, p. 216, fig. 76, a–g; OKUDA, 1936, p. 151, fig. 5; PETTIBONE, 1954, p. 309, fig. 35, a, b.

Occurrence: St. 4.

Two specimens of which the anterior body was not everted, measure 11 and 12 mm in length respectively. The skin is densely covered with small papillae, more or less regularly spaced, and they are entangled with fine particles of mud. The anterior spines (Fig. 10, a–b) of the 2nd, 3rd and 4th segments were examined by dissection. These spines have the long characteristic, transparent tip. The caudal shield in the posterior region consists of two plates and it is about 7 mm in width, 4 mm in the longest longitudinal length. They have a series of ridges radiating from the centre, of which two conspicuous ridges divide it into three unequal areas. Accessory plates, anterior pair of the shield which is covered by the skin, are slightly transparent and of the two specimens one possesses 4–5 denticules in the anterior border of this plate (Fig. 10 c), the other having a normal anterior ridge, without any denticles. The form of the anterior border of the accessory plates seems to vary to some extent. The posterior plates are slightly convex in the posterior border and have a longitudinal deep notch. Numerous bundles of setae are present around the caudal shield; there are ten pairs of setae in the lateral sides of the shield, those at the outer posterior angles are especially long; and also 6–7 pairs of bundles are situated at the posterior border. The setae of those bundles are longitudinally striated, slender and covered with fine short hairs. There are blend with 6–7 very long capillary setae in only one bundle at each caudolateral corner and are nearly as long as that of the anterior body. Concerning the affinity of the present species to *S. costata* recorded by MARENZELLER from Japan, OKUDA (1936) thoroughly discussed it.

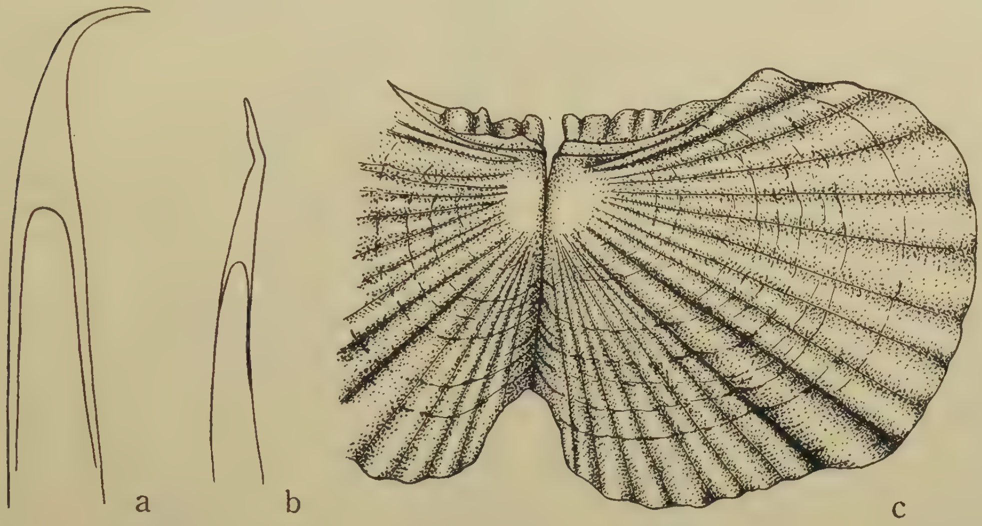

Fig. 10. *Sternaspis scutata* (RANZANI).
a–b, Anterior spines. ca. ×150; *c*, Caudal shield, left part omitted. ca. ×20.

Family AMPHARETIDAE

Amphicteis scaphobranchiata MOORE

(Text-fig. 11, a–c)

Amphicteis scaphobranchiata: MOORE, 1906, p. 255, pl. 22, figs. 54–61; BERKELEY and BERKELEY, 1952, p. 68, figs. 139–141.

Occurrence: St. 1, 1 spec.; St. 10, 1 spec.

Two specimens are examined, of which one specimen is particulary well preserved. The large one measures 56 mm long. They are 17 thoracic setigerous segments and 15 abdominal segments. The median lobes of the prostomium are almost parallel, slightly diverging anteriorly. There are four pairs of branchiae, one of which is subterminally broad and then narrows and bends on itself into a hook (Fig. 11 a). Paleae are well developed and extend slightly beyond the prostomium. They are 21–23 in number, and have very long, acute tips (Fig. 11 b). Uncini have 5–6 teeth, with a process between the last and the antero-inferior end of the hook (Fig. 11 c). The tube is membranous, coated with greyish mud.

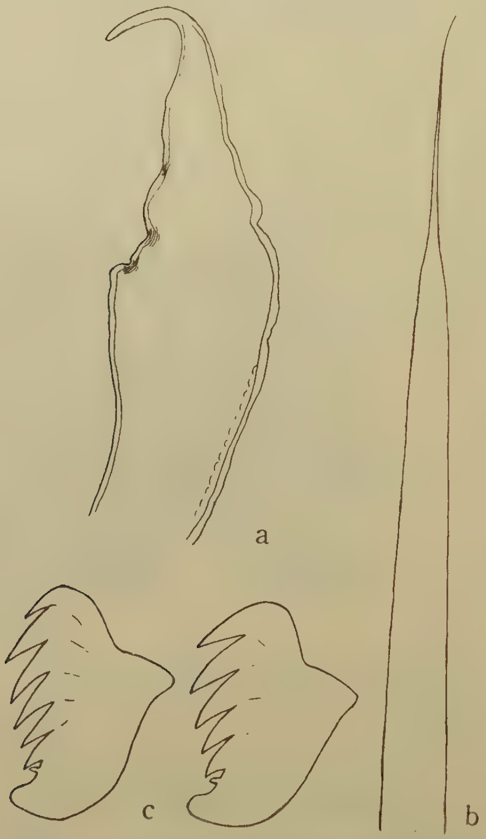

Fig. 11. *Amphicteis scaphobranchiata* MOORE.
a, Anterior end of specialized branchia. ca. ×10 ; *b*, Palea. ca. ×60 ; *c*, Abdominal uncinus. ca. ×180.

Family TEREBELLIDAE

Terebellides stroemi SARS

Terebellides stroemi: FAUVEL, 1927, p. 291, fig. 100; BERKELEY and BERKELEY, 1952, p. 75, figs. 152, 153.

Occurrence: St. 13.

A single specimen measures 65 mm for 56 setigerous segments. Thoracic

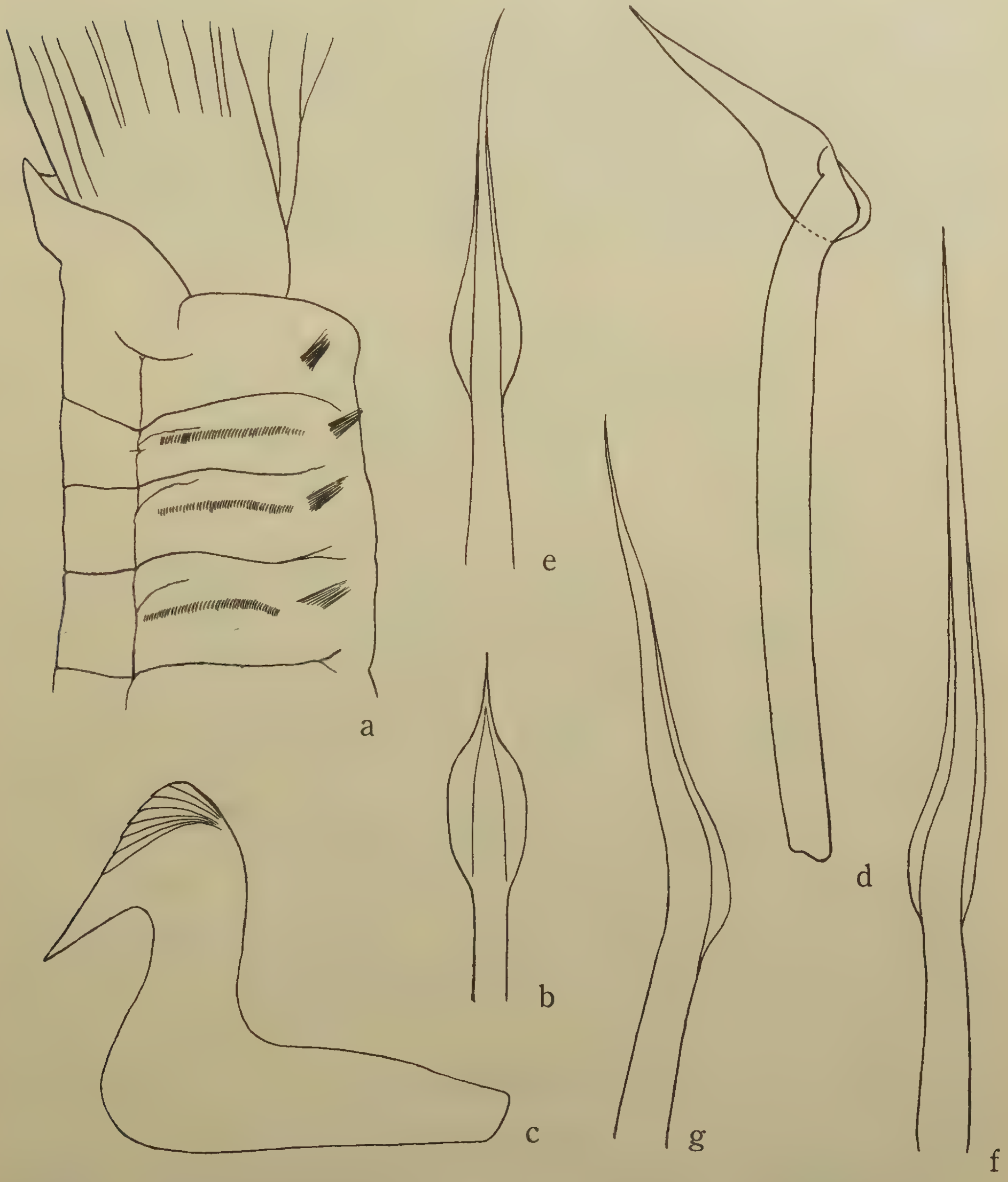

Fig. 12. *Potamilla neglecta* (Sars).

a, Anterior region of body, lateral view, end of branchial filaments removed. ca. ×13; *b*, Spatulate seta from thoracic segment. ca. ×420; *c*, Avicular uncinus from thoracic segment. ca. ×600; *d*, Pennoned seta from thoracic neuropod. ca. ×600; *e–g*, Abdominal neurosetae. ca. ×420.

setigerous segments are 18 in number. A pair of branchiae with a heavy trunk arises from the second and third segments, and the third one is a solid mass and divided into four pectinate branches. The dorsal bladed capillary setae begin at the 3rd segments. The crotchets of the thoracic region are first present from the 8th neuropodium and continue back to the end of this region; they are a long, slightly curved shaft with a crown of small teeth. The abdominal nucini has some teeth arranged in a crown on the main fang.

Family SABELLIDAE

Potamilla neglecta (SARS)

(Text-fig. 12, a–g)

Potamilla neglecta; EHLERS, 1908, p. 154, pl. 22, figs. 5–17.

Occurrence: St. 6.

A single complete specimen measures 47 mm including the branchiae which measures 10 mm. There are 92 setigerous segments, 8 thoracic and 74 abdominal. The branchiae are 12 filaments on each side. There is no eye. The collar is vertical and almost meeting at the dorsal surface, and is extended ventrally into a long triangular point. There are scanty incisions at the lateral side (Fig. 12 a). The collar setae are the only bladed capillary setae and spatulate setae with finely pointed tips which are present on the notopodium (Fig. 12 b), and there are also avicular uncini (Fig. 12 c) and pennoned setae (Fig. 12 d) on the neuropodium. In the abdomen notopodial avicular uncini are similar to thoracic ones, and the neurosetae consist of two sorts of setae; the one long, symmetrically or asymmetrically double-winged capillary setae (Fig. 12 e–g) and the other short, spatulate setae similar to those of the thoracic one. The feature of collar and setae corresponds well with EHLER's descriptions and figures.

Chone infundibuliformis KRÖYER

(Text-figs. 13, a–b and 14, a–f)

Chone infundibuliformis: MALMGREN, 1865, p. 404, pl. 38, fig. 87; FAUVEL, 1927, p. 334, fig. 116; BERKELEY and BERKELEY, 1952, p. 123, figs. 252, 253; PETTIBONE, 1954, p. 338, fig. 39.

Occurrence: St. 6.

A colony consisting of 8 tubes were collected. The specimens are 31–44 mm in total length, of which the branchial length measures 11–13 mm. There are 50–56 setigerous segments, the thorax consisting of 8 setigerous segments. The collar, well developed, is complete at the ventral side and on the dorsal side almost meets and the deep incision continues to the end of the 2nd chaetiger. The 2nd setigerous segment bears a row of glands in a white transversal band (Fig. 13 a–b). Branchial filaments bear 11–14 filaments on each lobe. In the specimens I examined there are not so many branchiae as in FAUVEL's description. The branchial tip is more or less foliaceous, and some specimens bear very long terminal barbules and they are long enough to cover the branchial tips as shown in *Chone ecaudata*. But in the majority of the specimens terminal barbules do not reach the branchial tip (Fig. 14 a). The 1st setigerous segment bears only winged collar setae and fine winged geniculate setae. The notopodium of the thoracic segments contains three kinds of setae: long winged capillary setae, spatulate setae with mucrons of moderate length, and geniculate setae (Fig. 14 b–d). In the thoracic neuropodium there are found only stout crotchet setae (Fig. 14 e). In the abdominal segments the notopodium has a row of uncini which bear 3–4 teeth at the side (Fig. 14 f), and the neuropodium has winged capillary setae which are longer than those in the thoracic segments.

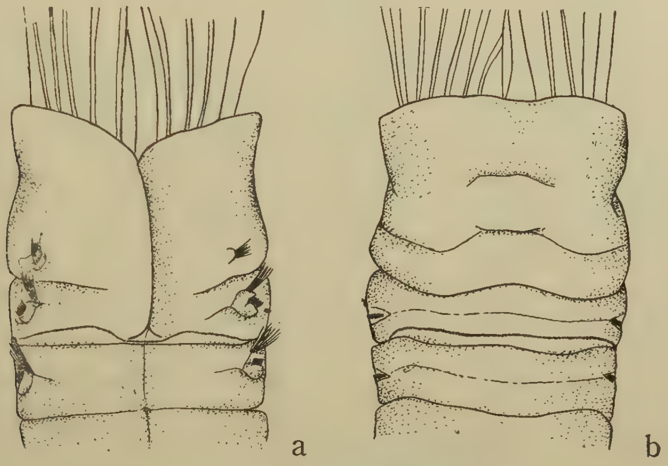

Fig. 13. *Chone infundibuliformis* KRÖYER.
a, Anterior region, dorsal view; *b*, Anterior region, ventral view. All end of branchial filament omitted. ca. ×15.

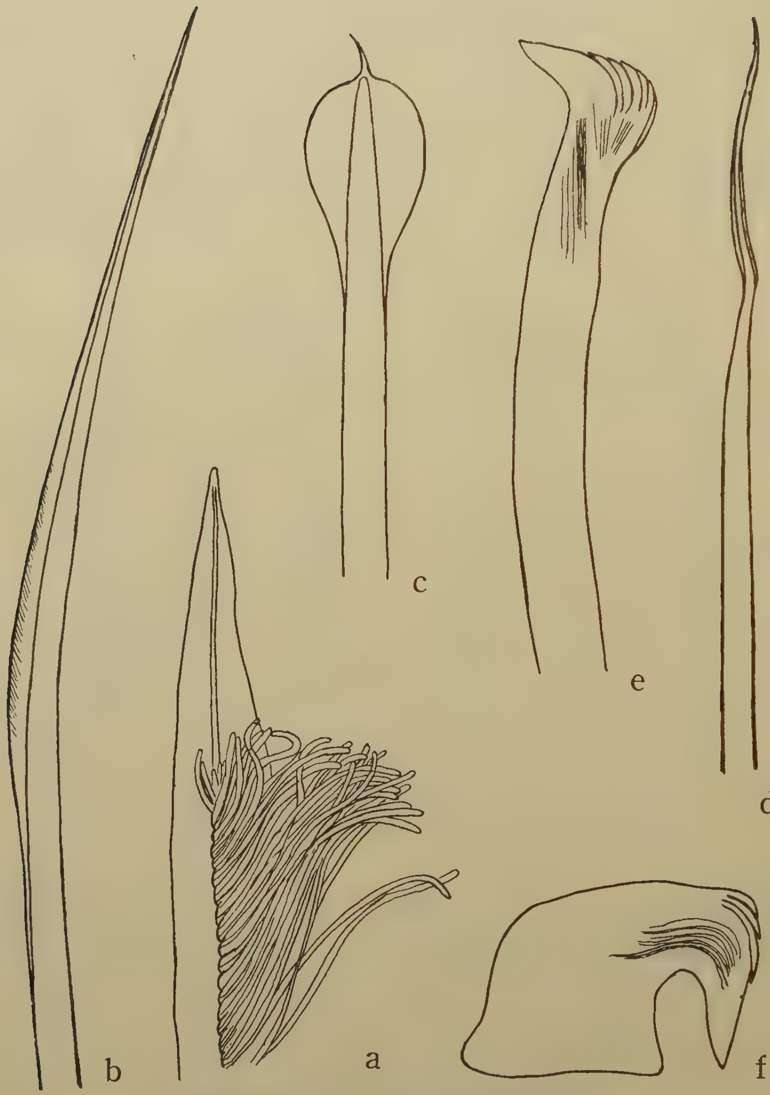

Fig. 14. *Chone infundibuliformis* KRÖYER.
a, Tip of branchial filament. ca. ×25; *b*, Thoracic capillary seta. ca. ×420; *c*, Thoracic spatulate seta from 5th chaetiger. ca. ×420; *d*, Thoracic geniculate seta. ca. ×420; *e*, Crotchet seta from 4th thoracic neuropodium. ca. ×600; *f*, Abdominal uncinus. ca. ×600.

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ASCIDIANS COLLECTED DURING THE MELANESIA EXPEDITION OF THE ÔSAKA MUSEUM OF NATURAL HISTORY

I. ASCIDIANS PRESENTED BY DR. R. L. A. CATALA OF THE AQUARIUM OF NOUMEA[1,2]

Takasi TOKIOKA

Seto Marine Biological Laboratory, Sirahama

With Plate V and 15 Text-figures

During my stay at Noumea, New Caledonia, in the autumn of 1958, I often visited the Aquarium of Noumea to enjoy the beautiful collection of marine animals of the tropical sea and had fortunately a chance to see Dr. R. L. A. Catala who established this aquarium and asked him for some specimens of ascidians. Very generously, Dr. Catala offered me all the specimens he had kept in his laboratory. These include fourteen species listed below.

1. *Polyclinum constellatum* Savigny
2. *Didemnum (Didemnum) moseleyi* (Herdman)
3. *Ascidia gemmata* Sluiter
4. *Ascidia sydneiensis samea* (Oka)
5. *Phallusia julinea* Sluiter
6. *Botryllus gracilis* Michaelsen
7. *Symplegma oceania* n. sp.
8. *Polyandrocarpa (Polyandrocarpa) rollandi* n. sp.

8*a*. *Polyandrocarpa (Polyandrocarpa) rollandi* f. *solitaria* nov.

9. *Polycarpa cryptocarpa* (Sluiter)
10. *Polycarpa aurata* f. *clavata* Hartmeyer
11. *Cnemidocarpa areolata* (Heller)
12. *Styela partita* (Stimpson)
13. *Herdmania momus* (Savigny)
14. *Microcosmus* sp. aff. *multiplicatus* Tokioka

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1) Scientific Results of the Melanesia Expedition, No. 9.

2) Contributions from the Ôsaka Museum of Natural History, No. 69 and Contributions from the Seto Marine Biological Laboratory, No. 363.

Publl. Seto Mar. Biol. Lab., IX (1), 1961. (Article 8)

Ascidia sydneiensis samea, *Phallusia julinea*, *Herdmania momus* and *Microcosmus* sp. aff. *multiplicatus* were included in the collection made by Dr. CATALA himself, while *Polycarpa aurata* f. *clavata* was collected by Dr. YVES MERLET by diving and twelve species exclusive of *Phallusia julinea* and *Polycarpa aurata* f. *clavata* were found in the samples collected by Mr. ROLLAND from the bottom of a vessel. I want to express here my hearty thanks to Dr. CATALA for his kindness in submitting these specimens to my examination.

1. *Polyclinum constellatum* SAVIGNY, 1816

(Pl. V, fig. 1; Text-fig. 1)

Seven large colonies, up to 70 mm × 50 mm in extent, and fourteen small ones in the collection. They are encrusting or massive, and the thickness or height varies in the range from 4 mm to 25 mm. The test is soft gelatinous, translucent, and brownish, dark purplish brown or purplish black in colour in preservation. The surface is generally smooth or marked with slight elevations and depressions arranged irregularly; it is usually free from any foreign materials, although sometimes it is sparsely encrusted with fine sand grains. Systems of the arrangement of zooids cannot be discerned clearly on preserved specimens; they must be very complicated as the atrial languet of zooid is very elongate. There are several oval common cloacal apertures on the surface of the colony, they are 0.5 mm to 3 mm in diameter. The zooidal layer is about 5 mm thick. The living colonies are coloured greenish gray or orange red and the branchial apertures are marked each with six prominent lobes.

Zooid: Thorax is about 1.5 mm in length, abdomen is about 1 mm long, and postabdomen may often be longer than abdomen. About seven longitudinal muscles on each side of thorax. Stigmatal rows are 14 to 17, most frequently 16; sometimes the stigmatal rows are one more on the left side than on the right side. Twelve to sixteen stigmata in each row, dorsal languets are slightly displaced to the left side from the dorso-median line. Anus is bilobed and opened at the level of the 8 th or the 9 th transverse vessel. Tentacles of the first and the second orders are 16, in addition to them smaller ones of the third order intervene between larger ones; thus the arrangement of large-small-medium-small-large is seen in most zooids. Ciliated groove is a small oval opening. Both hind-stomach and middle intestine are defined distinctly. Up to 20 testicular follicles in postabdomen, ovary is situated at the centre of the gonad. Embryos in the incubatory chamber are less than two in examined zooids, they are 410–550μ in length and provided with three attachment processes arranged linearly and four pairs of ampullae. Pigment flecks of the sensory organ are arranged antero-posteriorly or slightlly obliquely. Larval test is granulated.

There is another small colony, 12 mm × 7 mm in extent and 4 mm in thickness

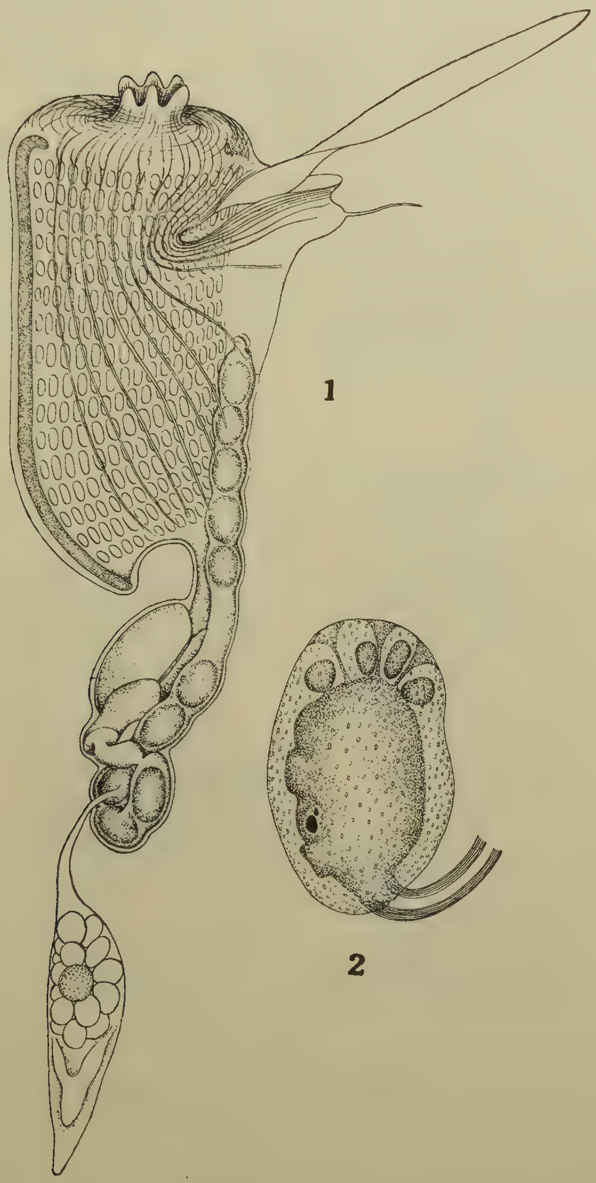

Fig. 1. *Polyclinum constellatum* Savigny. 1—Left side of a zoid, 2—Right side of an embryo, ×73.

The test is soft gelatinous, milky-white and translucent so that brownish zooids are seen through. The surface is smooth and quite free from any foreign materials. The type of systems found in the arrangement of zooids is hardly discriminated on the colony surface, although they do not seem to be stellate. Thorases are 1.5 mm in length and abdomens are about half as long as thorases. The arrangement of the thoracic musculature is quite the same as that mentioned above. Atrial languet is of a moderate length. A small 700μ long thorax is found having 9 stigmatal rows, each carrying ca. 8 stigmata on each side; but usually there are 12–14 stigmatal rows in larger zooids and about 13 stigmata are found in each row. Anus is located at the 8th transverse vessel in zooids with 14 stigmatal rows. Although the existence of fewer stigmatal rows in smaller zooids reminds us of *P. tsutsuii* Tokioka known from the tropical and subtropical areas of the North West Pacific, this colony may represent most probably a young colony of *P. constellatum.*

2. *Didemnum* (*Didemnum*) *moseleyi* (Herdman), 1886

(Text-fig. 2)

Many colonies encrusting the nest tubes of a polychaete and barnacles, the largest one of which is about 80 mm × 50 mm in extent. They are irregularly lobated end the surface is quite uneven. They are thin, mostly less than 1 mm in thickness. The surface is slightly grayish white in colour and in some colonies, it is divided by grooves into a number of small areas. Systems indiscernible, branchial apertures are marked with six lobules The superficial spiculeless layer is not defined in these colonies. Spicules are distributed densely in the surface layer of the thoracic stratum, but very sparsely in other layers, so that the

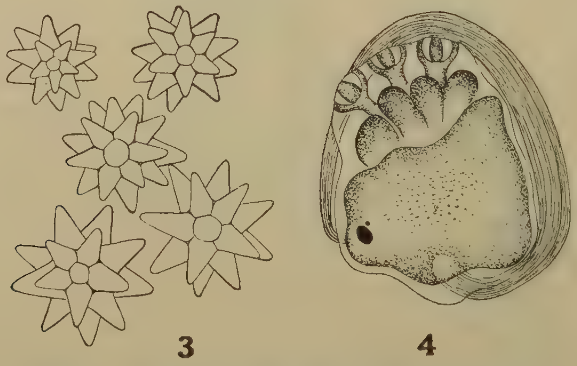

Fig. 2. *Didemnum* (*Didemnum*) *moselyi* (Herdman). 3—Spicules, ×440; 4—Right side of an embryo, ×73.

underside of the colony looks yellowish brown. Spicules rather small and stellate in shape, 24–44μ in diameter and with an average of 33μ; rays on the equatorial plane are usually 8–10, sometimes up to 12.

Thorax is 580–690μ long and with an average of 650μ, abdomen is up to 550μ in length. Atrial aperture very wide. About six stigmata in each of four rows. Testicular follicle one, the proximal end of the vas deferens coils about five times. Embryos are about 450μ in length and with three cup-shaped attachment processes arranged lineally and furnished at the basse with four pairs of ampullae; pigment flecks of the sensory organ arranged obliquely.

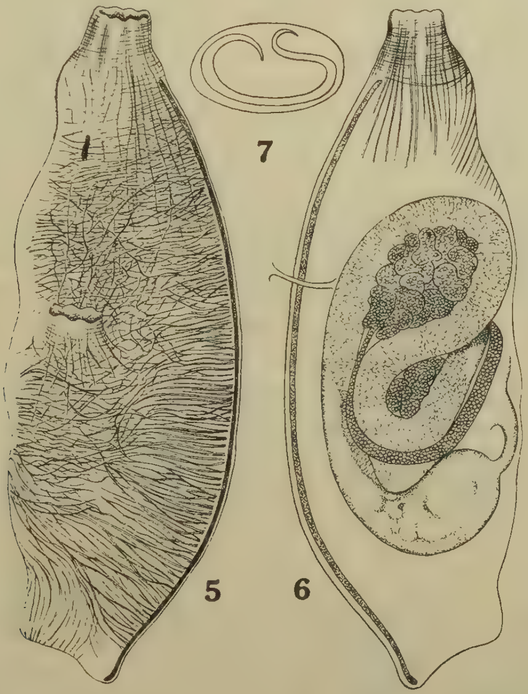

Fig. 3. *Ascidia gemmata* SLUITER. 5—Right side of the mantle body of a 50 mm long individual, 6—Left side of the same mantle body, 7—Ciliated groove of the same individual.

3. *Ascidia gemmata* SLUITER, 1895

(Text-fig. 3)

Four specimens in the material, they are respectively 13, 23, 35 and 50 mm in length. The animal is oval in shape, flattened laterally and attached to the substratum by the whole left side. The test is rather hard gelatinous, translucent, faintly milky white in colour and thicker than in next *A. sydneiensis samea.*

The surface is originally smooth, but becomes rather irregular, probably because of contraction and at the same time by being fouled with creeping hydrozoan colonies; it is papillated (?) in some specimens. Branchial siphon terminal; atrial siphon is situated at the level of the posterior one-third in three smaller specimens, but in the largest 50 mm long specimen it is located with the posterior edge of its base at the middle. Siphons are short in the present specimens. The right surface of the mantle body is wholly reticulated with fine muscles chiefly consisting of transverse ones in the postero-ventral portion. The dorsal ganglion is apart from the ciliated groove for the distance approximately two times the ganglion length. Seven or eight ocelli at the branchial and six ones at the atrial aperture. Tentacles ca. 50 in the largest specimen, the order of large-small-medium-small-large may be discerned at some places; ciliated groove is simply U-shaped. There are 206 transverse vessels on the right side of the branchial sac of the 50 mm long specimen; they are arranged in the order of thick-thin-medium-thin-thick and partially intervened by parastigmatic vessels; inner longitudinal vessels are 38 on the left and 41 on the right side in the same individual. Plications are not so remarkable, about six stigmata on each plication; no intermediate papillae are found. The dorsal lamina is ribbed, the distal end of ribs is protruded out beyond the edge of the lamina in the posterior part. The anterior end of the intestinal loop reaches the middle of the range in front of the atrial siphon. The second intestinal loop is very deep with its axis passing through the proximal part of the intestine considerably apart from the pyloric end of the roughly globular stomach. The oesophagus opens to the branchial sac at the level of the anterior one third of the range behind the atrial siphon. The ovary is coloured in a characteristic dark purplish nuance.

4. *Ascidia sydneiensis samea* (Oka), 1935

(Text-fig. 4)

There are 12 specimens ranging from 11 mm to 71 mm in body length. The body is oval in outline, laterally compressed and attached to the substratum by the whole left side of the body. The test is hard gelatinous, usually milky white, translucent or transparent and very thin, being less than 1 mm even in larger specimens. The surface seems originally to be smooth, but usually it is furnished with many irregularly formed prominences by which the animal attaches to other objects to keep its position and sometimes it becomes yellowish brown by being fouled with various organisms. The branchial siphon terminal, the atrial is situated at the middle of the body or nearby with the posterior edge of its base at the middle. Both siphons are fairly long; the atrial aperture is 6-lobed, while the branchial is 7–9 lobed; the margin of each lobe is pectinated. Mantle

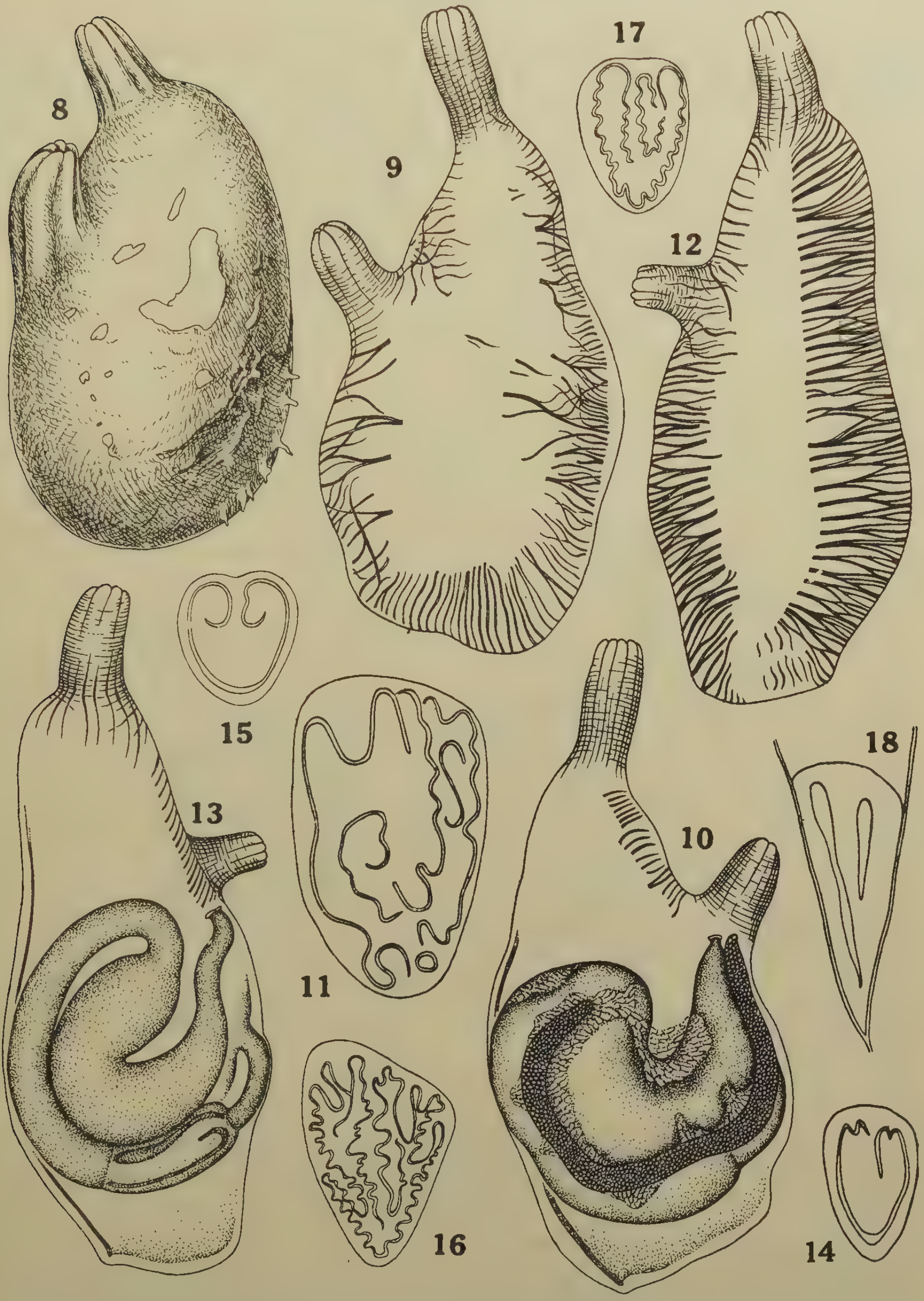

Fig. 4. *Ascidia sydneiensis samea* (Oka). 8—42 mm long specimen, 9—Right side of the mantle body of the same individual, 10—Left side of the same mantle body, 11—Ciliated groove of the same individual, 12—Right side of the mantle body of a 18 mm long individual, 13—Left side of the same mantle body, 14—Ciliated groove of the same individual, 15—Ciliated groove of a 19 mm long mantle body, 16—Ciliated groove of a 26 mm long mantle body, 17—Ciliated groove of a 42 mm long individual, 18—Ciliated groove of a 34mm long individual.

is grayish brown or dark brownish, the muscles are interrupted widely at the middle on the right side.

Body length	Tentacles	Transverse vessels	Longitudinal vessels
42 mm	ca. 100	129–130	48–52
42 mm	ca. 50*	—	47
34 mm	ca. 70*	133	49–51
18 mm	ca. 25*	70–70	37–42

* exclusive of minute ones.

Tentacles are 50–70 in grown ups when the larger and medium ones are counted, but they may be up to 100 when the smaller or minute ones intervening at intervals are counted together. The ciliated groove is U-shaped with both horns incurled in smaller (18 and 30 mm long) individuals, but it is undulating and complicated in larger specimens. The occurrence of a simple ciliated groove in the 34 mm long individual is rather unusual. There are about 130 transverse vessels on the branchial sac of grown up and usually 40–50 inner longitudinal vessels. Plications of the branchial sac are distinct, but not so remarkable, 4–6 stigmata (3 in smaller individuals) on each plication. Intermediate papillae absent. The dorsal lamina is ribbed, but the distal end of ribs does not project out beyond the margin of the lamina. The anterior end of the intestinal loop does not reach beyond the level of the base of the atrial siphon. The axis of the second intestinal loop passes through the pyloric portion of the stomach or the proximal portion of the intestine slightly apart from the pyloric end. Usually the bottom of the second intestinal loop is swollen remarkably in the present specimens. The stomach is elongate and smoothly surfaced, although a few plications of the inner wall may be seen through in some specimens. The 18 mm long individual is immature; but the specimens larger than 34 mm long are all matured; the ovary is borwnish in colour. Parasitic copepods were found in the branchial sac of some specimens and more frequently amphipods in the peribranchial cavity.

5. *Phallusia julinea* SLUITER, 1919

(Pl. V, fig. 2; Text-fig. 5)

A single 51 mm long specimen in the material. The animal is oval, laterally flattened and attached to the substratum by the whole left side. Test is rather thick, hard gelatinous, translucent and milky white in colour. The surface is generally smooth, but sparsely sprinkled with minute papillae. The test is wholly penetrated with many vessels ramified in a characteristic way ending in a number of blind terminals which are very frequently full of corpuscles. Branchial aperture is terminal and the atrial is situated at the level of the anterior one third of the body length,, both apertures are sessile. Mantle is delicate, the right side is wholly reticulated with muscles. Both branchial and atrial apertures are 10–lobed, ocelli are brownish in the preserved specimen, and the edge of each lobe of apertures is pectinated. Both siphons are very short. Tentacles ca. 75 in all, the arrangement of large-small-medium-small-large can be seen at some plasces. The main ciliated groove is simply U–shaped. Dorsal ganglion is situated far apart from the ciliated groove, approximately for the distance six times as long as the ganlion's length. No secondary ciliated grooves were found on the present specimen. There are 65–70 inner longitudinal vessels on one side and 181 transverse vessels on the right side of the branchial sac. About seven thinner vessels are found between each pair of thicker ones. Intermediate papillae absent. Plications of the branchial sac are inconspicuous, usually 3–4 stigmata at each interval between longitudinal vessels, but they may be up to 6 in the meshes found on rather strongly formed plications. Dorsal lamina is ribbed, the tip of ribs is protruded out beyond the edge of the lamina.

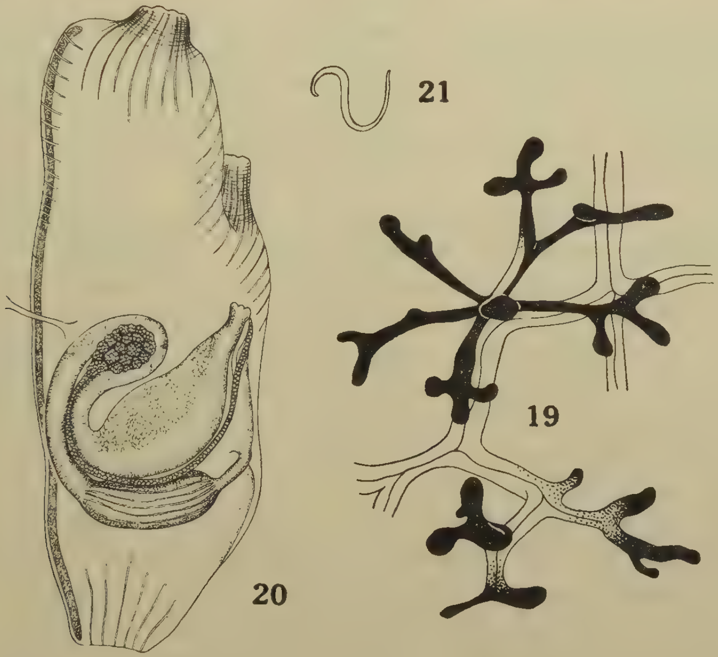

Fig. 5. *Phallusia julinea* Sluiter. 19—Vessels in the test, ×47; 20—Left side of the mantle body, 21—Ciliated groove.

The anterior end of the intestinal loop does not reach the level of the base of the atrial siphon. The second loop is well defined and deep, the proximal half of the distal branch of the second loop is characteristically swollen; the axis of the loop is passing through the proximal portion of the intestine somewhat apart from the pyloric end of the elongate stomach. About six longitudinal plications of the inner wall are seen through on the left side of the stomach. The oesophagus opens to the branchial sac at the level of the middle of the range behind the atrial siphon. The anal margin is undulating and forms several lobules.

6. *Botryllus gracilis* MICHAELSEN, 1927

(Text-fig. 6)

MICHAELSEN, W. (1927): Einige neue westaustralische Ptychobranchiate Ascidien. Zool. Anz., Bd. 71, p. 203.

HARTMEYER & MICHAELSEN (1928): Fauna Südwest-Australiens, Bd. 5, Lief. 6, pp. 338–341, text-figs. 22–23.

HASTINGS (1931): Great Barrier Reef Expedition 1928–29, Sci. Rep., Vol. 4, No. 3, pp. 77–79, text-fig. 4.

A considerable number of irregularly lobated colonies of various sizes encrusting barnacles and bivalves of the genus *Pinctada*. The largest one includes the portion about 30 mm × 20 mm in extent and 3 mm thick, but this shows the thickness of the folded part consisting of double zooidal layers opening on respective surfaces at some liberated part of the colony and the real thickness seems to be 1.5 mm. The surface is smooth and quite free from any foreign matters. The test itself is soft, gelatinous and transparent, and the purplish brown zooids are seen through. The system of the arrangement of zooids is quite obscure, probably because of the contraction of zooids.

Zooid: Most zooids are situated obliquely. They are usually less than 1 mm in length, although very extended ones may reach 1.8 mm. Larger fully grown zooids are usually pigmented very heavily and provided with the atrial aperture so wide that most parts of the branchial sac and even a part of the stomach are exposed at the maximum, while smaller or medium-sized ones are pigmented much less densely and have the small artial aperture (figs. 22, 24). Stigmatal rows are most freqently 8 on the right and 9 on the left side, though rarely they may be up to 10. The dorsal edge of the second row does not reach the dorso-median line, falling in the distance of two or three stigmata to the median line. Stigmata are distributed in respective interspaces between three inner longitudinal vessels as D. 3–4 : 2–3 : 2–3 : 3–4 V. Tentacles are 16 at the maximum, comprising 4 large, 4 medium-sized and 8 small ones intervening at each intervals between the first two. The ciliated groove is an oval orifice. The anus is attached to the brancial sac at the level of the 7th or the 8th transverse vessel and then extended further to the level of the 6th or the 7th transverse vessel; the margin is plain. The stomach is nearly spherical and its posterior half is exposed beyond the posterior margin of the branchial sac. Longtudinal plications on the stomach wall are most frequently 8 excluding the typhlosole, but rarely up to 9. The pyloric coecum is very large, strongly curved in a semicircular form and ending in a slightly swoollen tip. The intestine is rather short and stretched nearly straightly, the second intestinal loop is almost indiscernible. The proximal portion of the intestine adjoining to the stomach is slightly thinner than the following part and coloured differently. Gonads are seen most often on smaller zoooids and sometimes missing on one side. The left gonad is situated along the anterior margin of the intestinal loop, while the right one is located more posteriorly, with its posterior edge at the level of the rear end of the branchial sac. Testicular follicles are 2–3 in younger stage, but may be up to 12 at maturity. The ovary is situated at the anterior side of the testis and always contains only a single matured ovum; the egg develops to the embryo at this situation. A bud is protruded out from each body side near the antero-ventral corner of the testis.

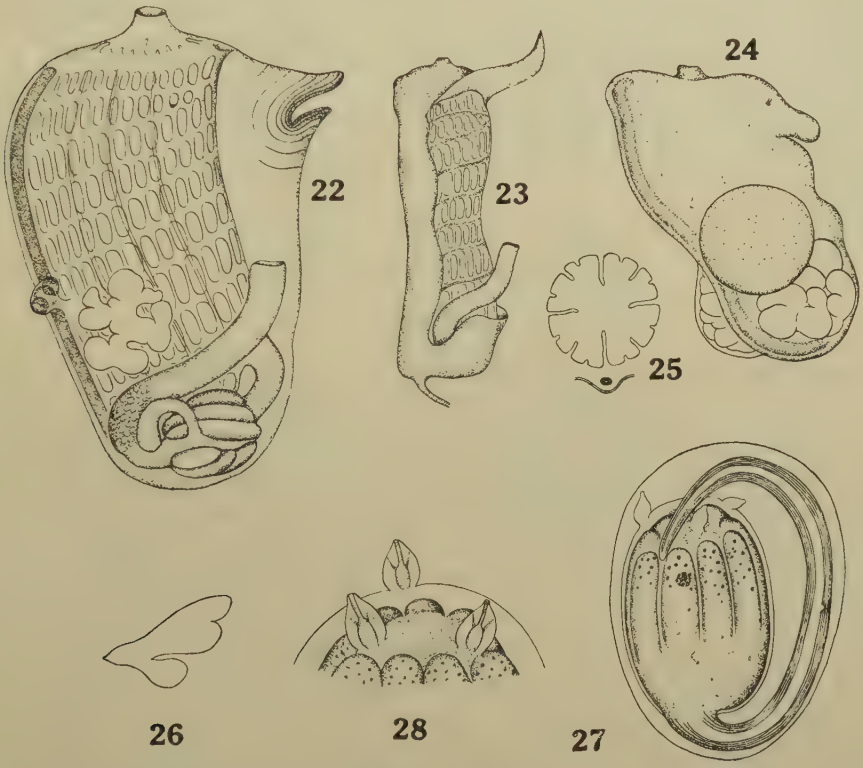

Fig. 6. *Botryllus gracilis* MICHAELSEN. 22—Left side of a young zooid, 23—Left side of an extended old zooid, 24—Young zooid with matured gonad, left side; 25—Tentacular ring and ciliated groove, 26—Left rudimentary testis, inner surface; 27—Embryo, ×73; 28—Attachment processes, magnified.

Larva: The trunk is ellipsoidal, 310–410μ in length and with an average of 350μ. Eight elongate ampullae are present. Three attachment processes are very prominent and arranged in a triangle. Pigment fleck of the sensory organ is situated slightly anteriorly to the middle of the trunk. Larval test is transparent, purplish brown pigments are deposited in the anterior part of the ampullae.

Remarks: The present colonies conform quite well to *Botryllus gracilis* described by MICHAELSEN (1928) and HASTINGS (1931). *Botryllus planus* (VAN NAME) has also a very conspicuous pyloric coecum and contains only a single mature ovum in the ovary, however this is provided with more stigmatal rows, usually 11–13, than in *B. gracilis*. Tentacles are 8 in *B. planus*. *Botryllus anceps* (HERDMAN) resembles the present species, too. It has 10–11 stigmatal rows on the branchial sac and 10 plications on the stomach. The difference between *B. anceps* and the present specimens is so exact that the identity of *B. gracilis* with *B. anceps* seems to be discussed fully in future on many specimens from various localities.

7. *Symplegma oceania* n. sp.

(Text-fig. 7)

Many colonies encrusting the nest tubes of a polychaetous annelid in a thickness of 2 mm. The surface of the colony is quite free from the foreign matters. The test is thin and transparent, but very tough in consistency. Zooids are oval in shape, up to 3 mm in length and covered by the purplish brown mantle which is sprinkled with reddish pigment spots on the dorsal side in some zooids. A thin reddish line encircles the branchial aperture opened subterminally. The atrial aperture is smaller than the brancial and situated approximately at the middle of the body. Both apertures are elongate along the sagittal axis of the body. Atrial tentacles are very fine. There are 13–14 stigmatal rows on the left and 13 rows on the right side on the ventral side, while 12–13 on the left and 12 on the right side on the dosal side. This difference is caused by the second row which falls in the distance of about six stigmata to the dorso-median line. Stigmata are divided by four inner longitudinal vessels into the following groups. D. 6–7 : 4–5 : 4–5 : 4–6 : 5–6 V; parastigmatic vessels absent. Tentacles 8, larger and smaller ones alternate regularly. Ciliated groove is a roundish orifice. The intestinal loop covers about 6 posterior stigmatal rows and its anterior margin reaches the 7th transverse vessel. The distal part of the intestine turns up onto the dorsal side and the anus is usually attached to the seventh transverse vessel, but extended further freely to the level of the sixth transverse vessel; anal margin is plain. The stomach is globular in outline, occupies one half of the proximal branch of the intestinal loop and marked with 13 longitudinal plications on the surface. The pyloric coecum is stout, not curved and issues a vessel from

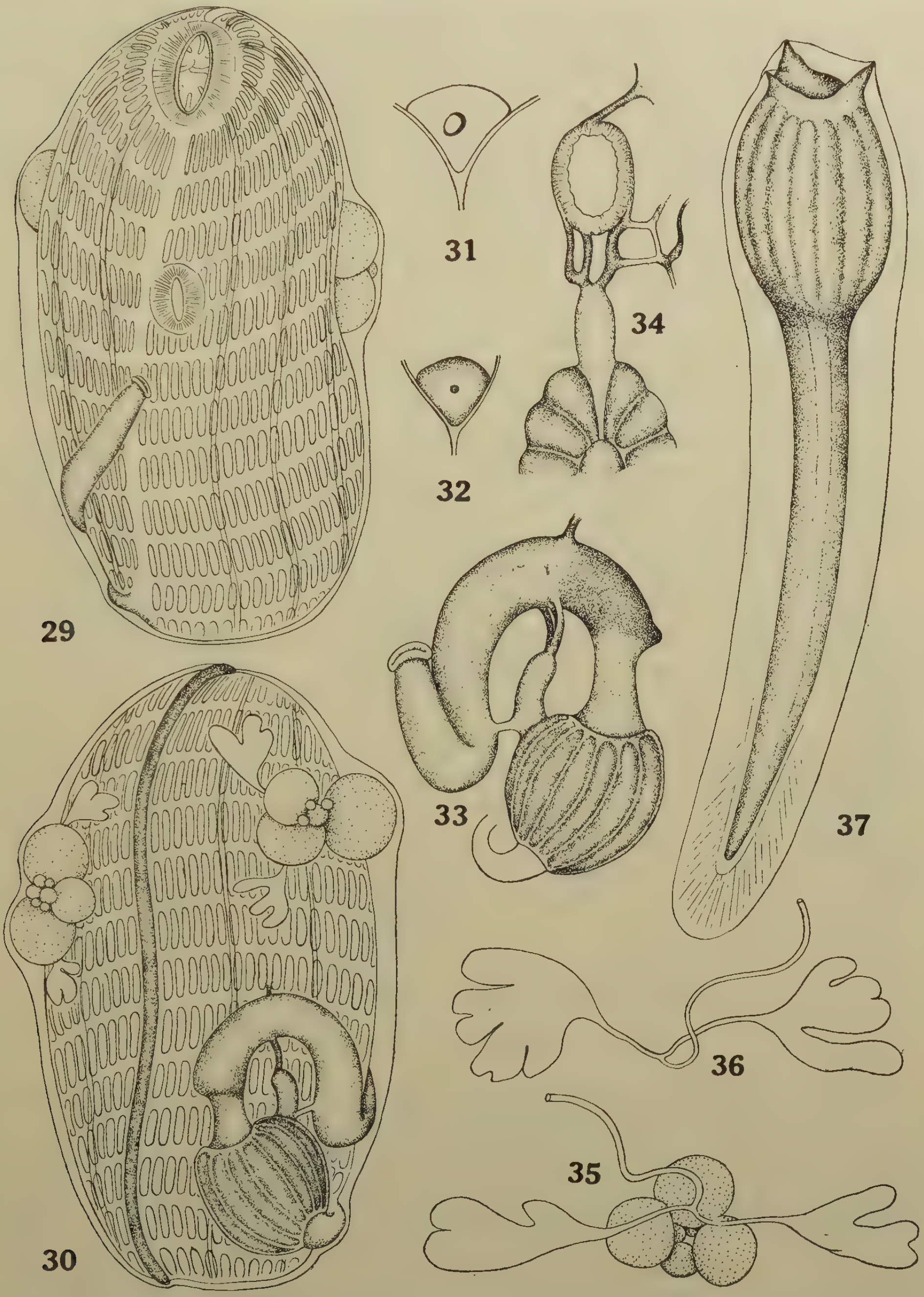

Fig. 7. *Symplegma oceania* n. sp. 29—Dorsal side of a zooid, 30—Ventral side of the same zooid, 31 and 32—Ciliated grooves, 33—Alimentary canal, 34—Pyloric coecum and vessels connecting it to the intestine, seen from the pyloric end of the stomach, above is shown the section of the intestine; 35—Testis and ovary, 36—Lobated testicular lobes, 37—Larva, ×73.

the base and two from the tip ; each of the two apical vessels is branched in a way shown in fig. 34 and branches are pigmented in purplish brown and distributed on the intestinal wall of the portion which is coloured somewhat orange. The middle intestine is defined clearly. One gonad on each side. The left gonad is situated at the middle of the range between the anterior end of the intestinal loop and the frontal end of the body and the right gonad is situated slightly anteriorly to the middle of the body, with its posterior margin at just the middle. Testis consists of two lobes, each is cut into two to four lobules which may be then subdivided, these lobules are coloured yellowish orange or reddish orange. Vas deferens is fine, but very long. Ovary is located at the middle between the pair of testicular lobes and usually contains one to three matured ova which are up to 400μ in diameter.

Larva: From two to four tadpole larvae are often found in respective zoooids. They are 1.5–1.7 mm in whole length, the trunk is up to 500μ in length. Sixteen elongate ampullae are present, three attachment processes are conical and arranged in a triangle. Larvae are coloured yellowish orange as well as matured ova.

Remarks: The present specimens resemble *Symplegma viride* Herdman in the number of stigmatal rows and in some zooids also in that of longitudinal plications on the stomach wall, however the shape of the pyloric coecum differs distinctly between these two. On the other hand, the present species conforms well to *S. reptans* (Oka) in the form of the pyloric coecum, but both the stigmatal rows and longitudinal plications on the stomach are comparatively fewer in *S. reptans* than in the present species. Moreover, the vessels connecting the pyloric coecum to the intestine is quite unique in the present species and this feature seems to be rather constant. For these reasons, the present specimens are considered to represent a new species clearly differentiated from both *S. viride* and *S. reptans*.

8. *Polyandrocarpa* (*Polyandrocarpa*) *rollandi* n. sp.

(Pl. V, fig. 3; Text-fig. 8)

Several colonies are found in the collection, two of them are large, respectively 70 mm × 50 mm and 50 mm × 45 mm in extent, and encrusting the dead barnacles, while others are very small. Larger colonies consist of numbers of considerably large zooids, 18 to 21 mm in length and about 20 mm in height, attaching to one anoter so tightly that their tests are fused one another. Thus, each individual has its own test on the dorsal side and zooids are not wholly embedded in the common test. The test is leathery, thin and about 0.5 mm in thickness, but tough in consistency; it is pale yellowish brown or light grayish brown on the surface and grayish on the inner surface, although it looks dark grayish brown when the mantle body is enclosed within it and the colour of the mantle is seen through. Both siphons are of a considerable length and distinctly 4-lobed. The surface of the test is generally smooth and exposed, although a little amount of sand and mud are seen deposited along the grooves formed between the zooids. The mantle is thin and coloured lightly in grayish purple brown, but siphons are pigmented rather heavily in dark brown. The branchial siphon is terminal and the atrial siphon is situated slightly posteriorly to the middle of the body, with the anterior edge of its base at just the middle. The atrial tentacles are fine, though very distinct. No endocarps are found on the inner surface of the mantle. The epithelium of the pretentacular stomodaeal

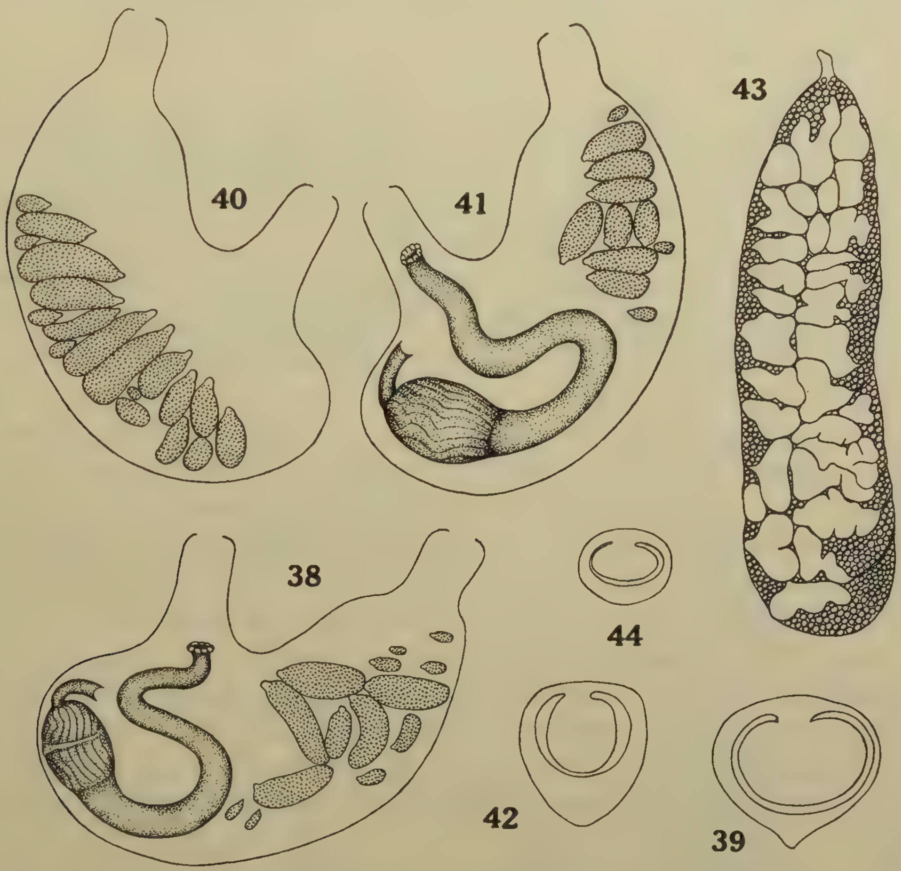

Fig. 8. *Polyandrocarpa* (*Polyandrocarpa*) *rollandi* n. sp. 38—Left half of the mantle body of a 18 mm long zooid, inner side; 39—Ciliated groove of the same zooid, 40—Right half of the mantle body of a 21 mm long zooid, inner side; 41—Left half of the same mantle body, inner side; 42—Ciliated groove of the same zooid, 43—A gonad from the same zooid, attachment surface; 44—Ciliated groove of another zooid.

portion is covered densely with small oval swellings which are 630–800μ in diameter and pigmented in dark purplish brown.

Branchial sac: Inner longitudinal vessels are arranged on four folds as follows:

18 mm long zooid											
Left	D.	3	(10)	7	(14)	5	(14)	5	(11)	6	V.
Right	D.	5	(11)	5	(13)	5	(14)	5	(11)	6	V.
21 mm long zooid											
Left	D.	5	(12)	8	(18)	6	(18)	7	(17)	5	V.
Right	D.	5	(11)	6	(16)	6	(17)	6	(13)	8	V.

Transverse vessels are arranged as 1 333 2 333 1 or 1 333 1, here the numerals represent the orders of the thickness; parastigmatic vessels are present, especially found frequently in the posterior part of the branchial sac. Three to four stigmata in each mesh, they are oval or elliptical. Tentacles 22–25, usually the order of large-small-medium-small-large is defined; besides them, minute ones are seen at some intervals. The ciliated groove is simply C–shaped, opened anteriorly.

Alimentary system: The anterior end of the intestinal loop scarcely reaches the middle of the body. The loop is wide; the second loop is distinct, its axis passes through the cardiac or middle part of the stomach. The stomach is elliptical, slightly shorter than a half of the ventral branch of the intestinal loop and furnished on the whole surface with longitudinal plications which are often curved complicatedly and about 10 on the free right surface, but attaining 17 on the whole surface in an examined individual. The pyloric coecum is absent. The anal margin is cut into about ten lobules which may be subdivided.

Gonad: Ten to fourteen gonads on the left and 14 to 22 on the right in dissected 18–21 mm long individuals. They are elongate and may attain 4 mm at the maximum; they are nearly liberated from the mantle, being fastened to it by only a few mesenterial filaments. Testicular follicles are arranged roughly in two rows on the attachment surface, each row consists of 10–12 follicles in larger gonads.

Remarks: The present specimens resemble closely *Polyandrocarpa* (*P.*) *sagamiensis* TOKIOKA 1953 in both the appearance of the colony and the structure and arrangement of internal organs. However, the former is differentiated clearly from the latter in the following three points; (1) the atrial siphon is situated more posteriorly as compared with that of *P. sagamiensis*, (2) the second intestinal loop is distinctly defined and (3) gonads are fewer than in *P. sagamiensis*, especially those on the left side are arranged rather irregularly. Amphipods are often found in the branchial sac. The species is dedicated to Mr. ROLLAND who collected the specimens.

8a. *Polyandrocarpa* (*Polyandrocarpa*) *rollandi* f. *solitaria* nov.

(Text-fig- 9)

Six individuals in the collection. They are 13 to 25 mm in body length and 6 to 8 mm in height in larger specimens, elongate ovoid in shape and attached to the substratum by the whole ventral side. Sometimes, the test is grown out as a membraneous extension from the periphery of the attachment surface. The

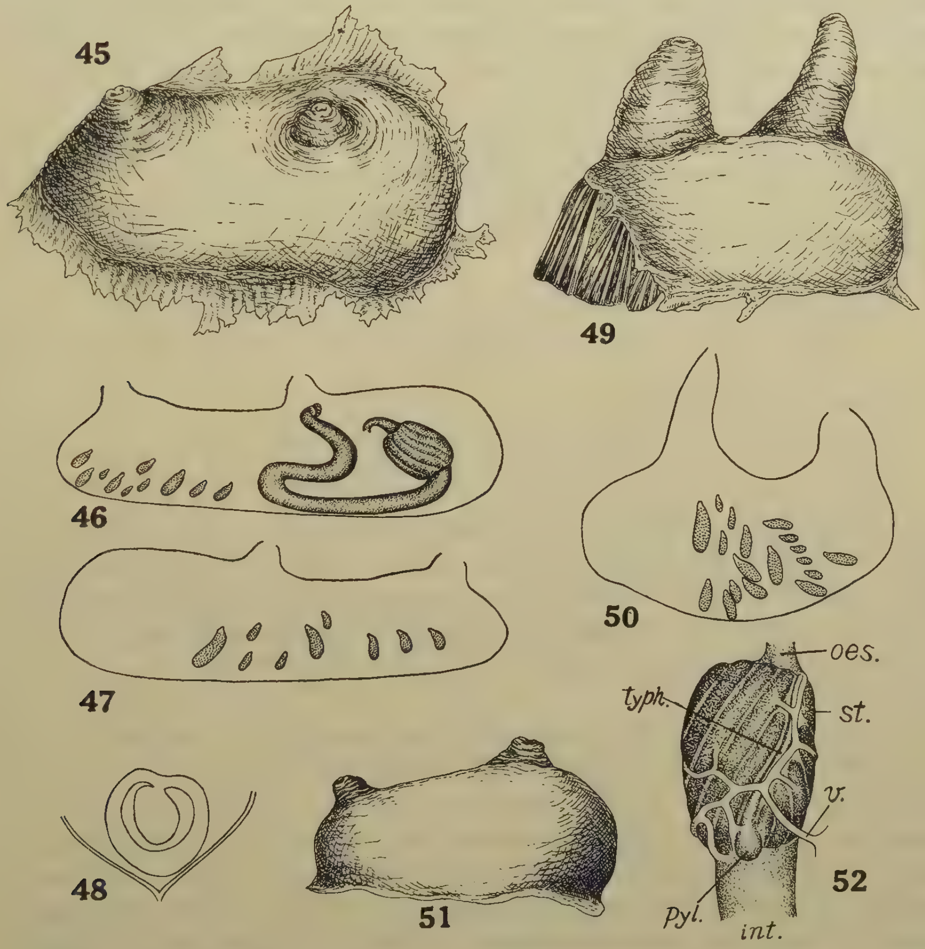

Fig. 9. *Polyandrocarpa* (*Polyandrocarpa*) *rollandi* forma *solitaria* nov. 45—25 mm long individual, 46—Left half of the mantle body of the same individual, outer side; 47—Right half of the same mantle body, outer side; 48—Ciliated groove of the same individual, 49—21 mm long individual, 50—Right half of the mantle body of the same individual, outer side; 51—22 mm long individual, 52—Dorsal side of the stomach of the same individual. int.—intestine, oes.—oesophagus, pyl—pyloric coecum, st.—stomach, typh.—typhlosole, v.—vessel.

branchial siphon is subterminal and the atrial is situated slightly behind the middle of the body with its anterior base at just the middle. Siphons are very short in some specimens, but they may be considerably long in others. The test is thin, less than 0.5 mm in thickness, translucent and light yellowish brown, brownish or grayish white in colour; both siphons are coloured darkly grayish brown. The surface is nearly smooth, but marked with irregularly formed wrinkles on or around the siphons; it is partially covered with mud or encrusted with some compound ascidians. The inner surface bears a pearly glistening. The mantle is very delicate and pale brownish in colour, the siphons are a little darker. The branchial siphon is terminal or subterminal on the mantle body. The pretentacular stomodaeal portion is covered with small oval swellings. Atrial tentacles very fine.

Branchial sac: Eight large, 8 medium-sized and 16 small tentacles are arranged in the order of large-small-medium-small-large; besides, minute ones at some intervals. The ciliated groove is C-shaped, opened anteriorly. Inner longitudinal vessels are arranged as:

22 mm long individual											
Left	D.	5	(12)	6	(14)	5	(13)	6	(10)	6	V.
Right	D.	5	(10)	6	(15)	6	(16)	6	(14)	6	V.
25 mm long indiuidual											
Left	D.	5	(9)	6	(11)	4	(13)	4	(11)	4	V.
Right	D.	4	(9)	5	(12)	4	(13)	4	(11)	5	V.

The dorsal-most inner longitudinal vessel in the first intermediate area between the dorsal lamina and the first fold is situated a little apart from others and slightly thicker. Transverse vessels are arranged in the order of thick-thin-medium-thin-thick and regularly intervened by parastigmatic vessels or partially transverse and parastigmatic vessels alternate rather regularly. Four to five stigmata in each mesh.

Alimentary system: The anterior end of the intestinal loop reaches the middle of the body. The second intestinal loop is very distinct in dorso-ventrally flattened specimens, but it is quite indistinct in globular individuals. The axis of the second loop passes through the pyloric end of the stomach which is oval in shape, smaller than one half of the ventral branch of the intestinal loop and provided with ca. 16 longitudinal plications on the whole surface. The pyloric coecum indistinct in some specimens, but a small but distinct one was observed in a 22 mm long individual. A prominent vessel is issued from the inner edge of the stomach at the level slightly posterior to the middle. The anal margin is cut into lobules, up to 14 in an examined specimens.

Gonad: A 25 mm long specimen has ten gonads on the left and nine on the right side, while another 21 mm long individual is provided on the right side wth 18 gonads arranged quite irregularly. Larger gonads may attain 4.5 mm in length, testicular follicles are generally arranged in two rows on the attachment surface. All the gonads are nearly liberated from the mantle surface.

Remarks: Evidently, both the external and internal structures of the present specimens conform well to those of zooids of the preceding species, excepting that the present specimens live solitarily. Very probably these are nothing but the solitarily living individuals of the preceding species. Slight differences found in the appearance of the alimentary canal, for example the formation degree of the second intestinal loop and the direction of its axis, seem to be attributable to the shape of the body. It is very difficult to judge which of the solitary form or the colony-forming form is the original form of the present species. If the solitary form is the fundamental form of the species, then the species should be treated as a form of the genus *Polycarpa*, contrarily it must be named as a species belonging to the genus *Polyandrocarpa* (*Polyandrocarpa*) if the colony formation is the general feature in this species. At present, most of specimens were found aggregated so firmly as to form colonies and only several specimens were found solitarily. Thus, it is the more appealing that the colony-forming forms are the original ones of the species and the genus *Polyandrocarpa* (*Polyandrocarpa*) is here adopted for the species.

9. *Polycarpa cryptocarpa* (SLUITER), 1885

(Text-fig. 10)

Styela cryptocarpa—SLUITER, C. PH. (1885): Ueber einige einfache Ascidien von der Insel Billiton. Natuurh. Tijdschr. Ned.-Ind., Vol. 45, pp. 210–215, Pl. 7 figs. 1–3.

Polycarpa cryptocarpa—HARTMEYER (1906): Zool. Anz., Bd. 31, p. 17.

OKA, A. (1915): Mem. Indian Mus., Vol. 6, pp. 17–18, Pl. 1 fig. 13.

HASTINGS (1931): Great Barrier Reef Exped., Sci. Rep., Vol. 4, No. 3, p. 75.

TOKIOKA (1950): Publ. Seto Mar. Biol. Lab., Vol. 1, No. 3, pp. 139–143, text-figs. 16–17, Pl. 10 figs. 2–3.

KOTT (1957): John Murray Exped. 1933–34, Sci. Rep., Vol. 10, No. 4, pp. 145–146.

Pandocia (*Polycarpa*) *cryptocarpa*—MICHAELSEN (1911): Mitt. Naturh. Mus. Hamburg, Vol. 28, p. 152.

A single 75 mm long specimen in the material. The body is considerably flattened laterally and attached to the substratum by the posterior end. The test is leathery, thick, 3–4 mm on most parts and attaining 5 mm near the posterior end, and brownish black in colour. The surface is wrinkled, gooved, and carries various foreign matters; especially some longitudinal grooves are prominent on the surface. The section of the test is grayish purple and the inner surface is also grayish purple and with a kind of pearly glistening. The branchial aperture is terminal, and the atrial aperture is situated near the branchial; both siphons are short and apertures are surrounded by soft purplish black test. The mantle is very thick, 2–2.5 mm in thickness, and purplish black on the outer muscular layer, while it is dark brownish on the inner layer where gonads are embedded. The inner surface of the mantle and the surface of visceral organs are sprinkled with a number of small roundish vacuoles which are 130–150μ in diameter and purplish black or dark brownish in colour, though they look orange brownish when they are examined in the light field under the microscope. The edge of the atrial velum is fringed with very fine tentacles.

Branchial sac: Tentacles are 22 when only large and medium-sized ones are counted; besides, there are two to three small or minute ones at each interval. The ciliated groove is divided into a number of small pieces. Inner longitudinal vessels are arranged as:

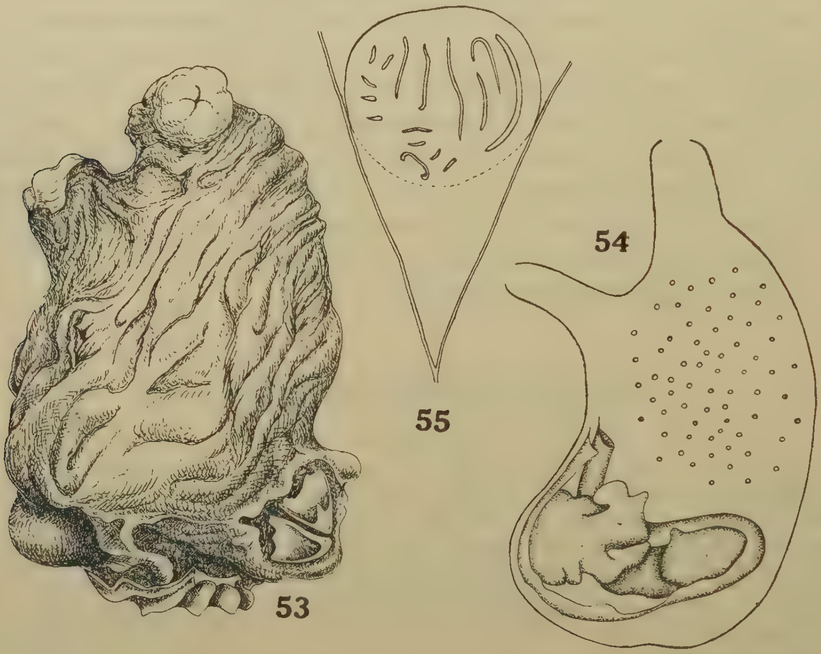

Fig. 10. *Polycarpa cryptocarpa* (Sluiter). 53—75 mm long specimen, 54—Left half of the mantle body, inner side; 55—Ciliated groove.

Left D. 2 (16) 4 (20) 6 (19) 5 (16) 4 V.
Right D. 4 (18) 4 (19) 5 (18) 5 (16) 2 V.

About seven thinner transverse vessels between each pair of thicker ones, parastigmatic vessels present. Up to ten stigmata in a mesh, they may attain 15 in large meshes along the endostyle.

Alimentary system and gonad: Probably the alimentary canal is on the way of regeneration as only the distal portion of the rectum remains perfectly, while other parts are represented by membraneous fragments. A large endocarp is found in the intestinal loop. The anal margin (?) is cut into a number of lobules. Gonads are distributed evenly on the inner surface of the mantle on both sides, about 65 on the left and about 80 on the right side; they are all buried in the mantle.

10. *Polycarpa aurata* (Quoy et Gaimard) f. *clavata* Hartmeyer, 1919

(Pl. V, fig. 4; Text-fig. 11)

Hartmeyer, R. (1919): Ascidien in Results of Dr. E. Mjöbergs Swedish Scientific Expeditions to Australia 1910–13. Kungl. Vet. Akad. Handl., Vol. 60, No. 4, pp. 40–44, Pl. I figs. 17–18.

Hartmeyer & Michaelsen (1928): Fauna Südwest-Australiens, Vol. 5, Lief. 6, pp. 363–366, text-fig. 28.

Kott (1952): Australian Jour. Mar. Freshwater Res., Vol. 3, No. 3, pp. 236–237, text-fig. 46.

There are five specimens of this curious pedunculate styelid collected by Dr. Yves Merlet from the rocky cliff 22 fathoms deep outside the barrier reef near Noumea in October 1958. Three of these specimens were presented to me for examination. They are respectively

	Trunk	Peduncle
No. 1	75 mm long	38 mm long and up to 6 mm thick
No. 2	91 mm long × 36 mm wide	15 mm long
No. 3	85 mm long × 37 mm wide	352 mm long.

The last specimen is preserved most perfectly and shown in Plate V fig. 4 and the second specimen was dissected to examine the inner structure. The peduncle is very short in the first two specimens, but this does not show the whole length of the peduncle, but only a small distal part adjoining to the trunk. The trunk is roughly elongate quadrate in outline, the branchial aperture is situated at the antero-dorsal corner, the atrial aperature is opened on the dorsal side approximately at the level of posterior one-third of the body length and the peduncle is issued from the antero-ventral corner of the trunk. Both siphons are very short, nearly sessile on preserved specimens. The test is soft cartilaginous or rather soft leathery. The surface is quite free from any foreign matters, but provided with several deep longitudinal furrows on each side; besides, a number of irregularly arranged transverse ones are present, thus the surface is divided into many small quadrate areas as seen in the figure of Plate V; the thickness is generally less than 3 mm. The peduncle seems to consist of three parts. For example, the peduncle of No. 3 specimen is described here. The proximal 135 mm (ca. 1/2.6 of the total length) is very hard, being 37 mm in diameter near the basal end, rather stiff in consistency and the surface is covered with many small algae. The distal 37 mm (ca. 1/9.5 of the total length) is of the medium thickness and as

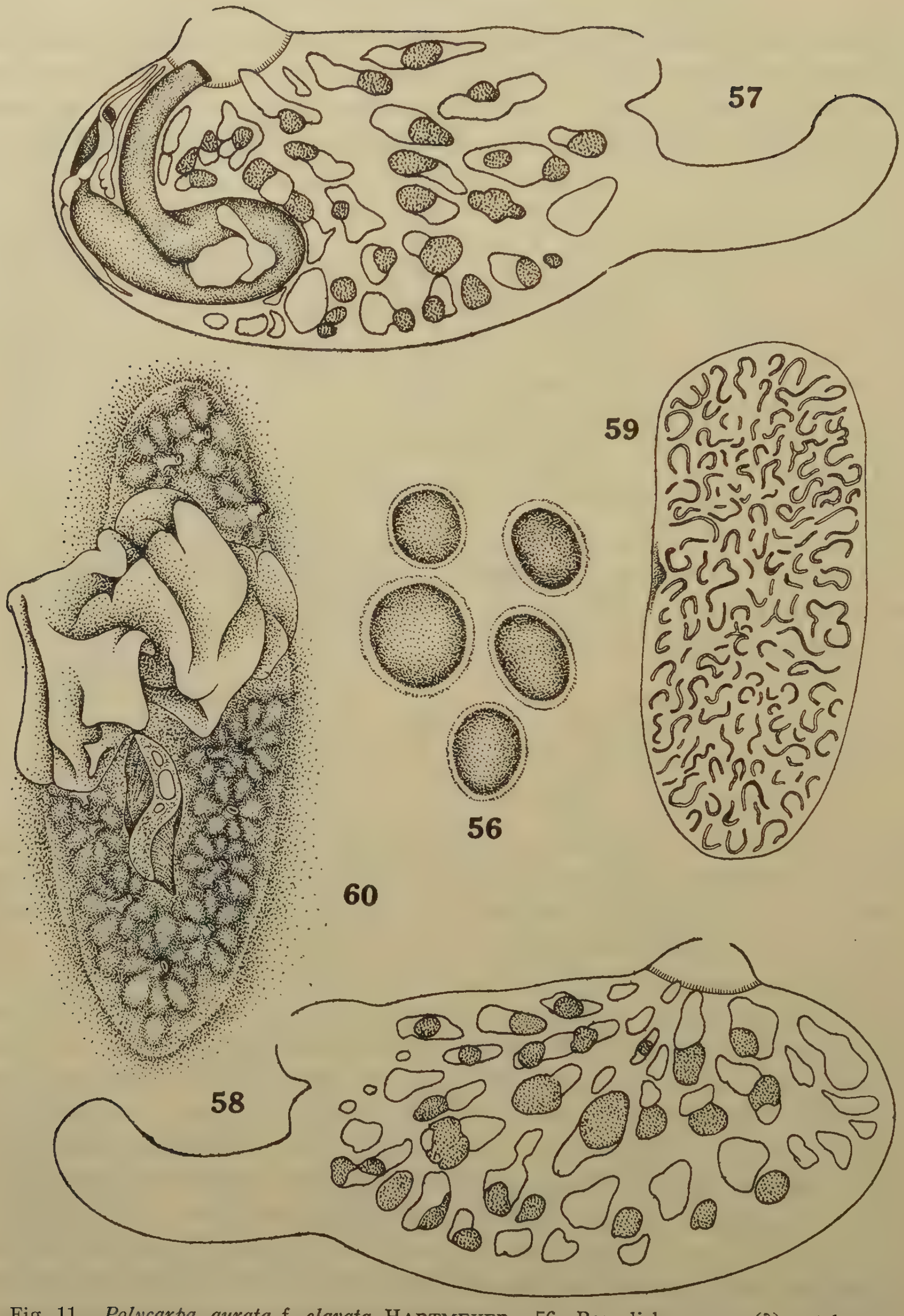

Fig. 11. *Polycarpa aurata* f. *clavata* HARTMEYER. 56—Roundish sensory (?) patches on the peduncular extension of the trunk, enlarged; 57—Left half of the mantle body of the 75 mm long (trunk length) specimen, inner side; 58—Right half of the same mantle body, inner side; 59—5 mm long dorsal tubercle of the same individual, 60—A 10 mm long gonad, a dozen genital apertures are shown on the surface.

evidently the extension of the trunk and provided with a number of small round sensory (?) patches scattered on the surface, these patches are usually ca. 1.5 mm in diameter. The rest 180 mm, about a half of the whole peduncle, is thinner than other parts, very soft and translucent in consistency and quite free from the foreign matters. The whole animal is coloured beautifully in red orange, not only on the external surface of the body but also on the whole internal organs such as branchial sac and alimentary canal, although it is somewhat paler on the soft part of the peduncle. The sensory patches on the distal part of the peduncle are somewhat grayish in colour. According to Dr. CATALA who kept this ascidian alive for a while in his aquarium and made detailed observations on this animal, the animals bore a quite pilose appearance when they were brought from the reef, but after four hours one of the specimens took off the pilose epidermis just as in the moulting. The specimen No. 2 is still holding the pilose epidermis, a gelatinous coat, on the basal half of the trunk. When the epidermis was removed, the coloured test surface looked quite fresh and beautiful*. The animals retained their perfectly erect posture for four days and they were swinging the trunk, just as the carnival doll swings its head with their apertures being alternately opened and closed while they were alive. The mantle is muscular, of a moderate thickness and with a number of endocarps scattered over the inner surface. Fine atrial tentacles are set densely on the atrial velum.

Branchial sac: The inner longitudial vessels are arranged as follows in the specimen No. 1:

Left	D.	4	(20)	5	(22)	5	(24)	4	(22)	3	V.
Right	D.	6	(25)	5	(23)	5	(21)	5	(18)	5	V.

Seven to twelve transverse vessels between each pair of thicker ones, the middle ones of which is usually slightly thicker than others; parastigmatic vessels are present, through they are very delicate; up to 15–20 stigmata in each mesh. Tentacles ca. 30 in No. 1 specimen, larger and smaller ones are differentiated and minute ones intervene at intervals. The dorsal tubercle is elliptical in shape and very large, about 5 mm in length; the ciliated groove is cut into about 140 small pieces in No. 1 specimen.

Alimentary system: The alimentary carnal is situated in the posterior one third of the left side and figures a S-shaped loop. The second intestinal loop is very distinct and its axis passes through the pyloric portion of the stomach which is elongate, slender and provided with ca. 25 longitudinal plications on the wall. These plications are, hower, invisible from the surface; pyloric coecum absent.

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* As to the moulting found in ascidians, K. KISHINOUYE (1894) stated that a specimen of *Halocynthia roretzi* DRASCHE was found moulting in the Inland Sea; the epidermis casted off was wrinkled and dirty brownish in colour, while the fresh test surface was bright reddish in colour (Zoological Magazine, Tokyo, Vol. 6, p. 342).

The anus is plainly margined. Two large endocarps are found in the first intestinal loop.

Gonad: In No. 1 specimen, there are ca. 35 gonads on the left and ca. 40 on the right side. Each gonad comprises a number of testes consisting respectively of several testicular follicles and having each a short duct. Usually one or two endocarps are found attached to the gonad.

Remarks: Although the remarkable colouration of those specimens and the existance of so long peduncle in some of the specimens fascinated me considerably, it is very evident that these are f. *clavata* of *Polycarpa aurata* (Quoy et Gaimard) described by Hartmeyer originally from North West Australia.

11. *Cnemidocarpa areolata* (Heller), 1878

(Text-fig. 12)

Cnemidocarpa irma—Hartmeyer & Michaelsen (1928): Fauna Südwest-Australiens, Bd. 5, Lief. 6, pp. 388–393, text-figs. 40–42.

Styela (*Cnemidocarpa*) *irma*—Kott (1952): Australian Jour. Mar. Fresh-water Res., Vol. 3, No. 3, pp. 217–218, text-fig. 11.

Six specimens are found in the collection. Two small individuals, respectively 4.5 mm and 8 mm in length, are devoid of any gonads and wear the thin whitish test, while other four 14 to 26 mm long individuals are provided with gonads of various grades of maturity. The body is roughly ovoid; the branchial aperture is terminal and the atrial is situated near or slightly in front of the middle of the body; both siphons are very short. The side of attachment is rather variable, some may be attached by the right ventral side. The test is soft cartilaginous, but tough, yellowish white or yellowish brown in colour and the surface is nearly smooth in some specimens, but may be grooved just as in *Styela plicata* in others. It is 1–2 mm thick, the inner surface is coloured as on the outer surface. The mantle is not thick, reddish brown in colour. The atrial siphon is located with the posterior edge of its base at the middle of the mantle body. Atrial tentacles are present. A few endocarps on the inner surface of the right side and a considerable number of them are arranged along the alimentary canal on the left side. Usually several endocarps are found in the intestinal loop. The swelling of the subneural gland is seen very distinctly on a 15 mm long individual.

Branchial sac: Inner longitudinal vessels are arranged as:

14 mm long specimen										
Left	D.	4	(9)	4	(11)	4	(11)	4	(9)	0 V.
Right	D.	0	(8)	4	(10)	4	(9)	4	(8)	3 V.
23 mm long specimen										
Left	D.	3	(11)	4	(13)	4	(14)	4	(11)	4 V.
Right	D.	0	(13)	3	(13)	4	(13)	3	(12)	4 V.

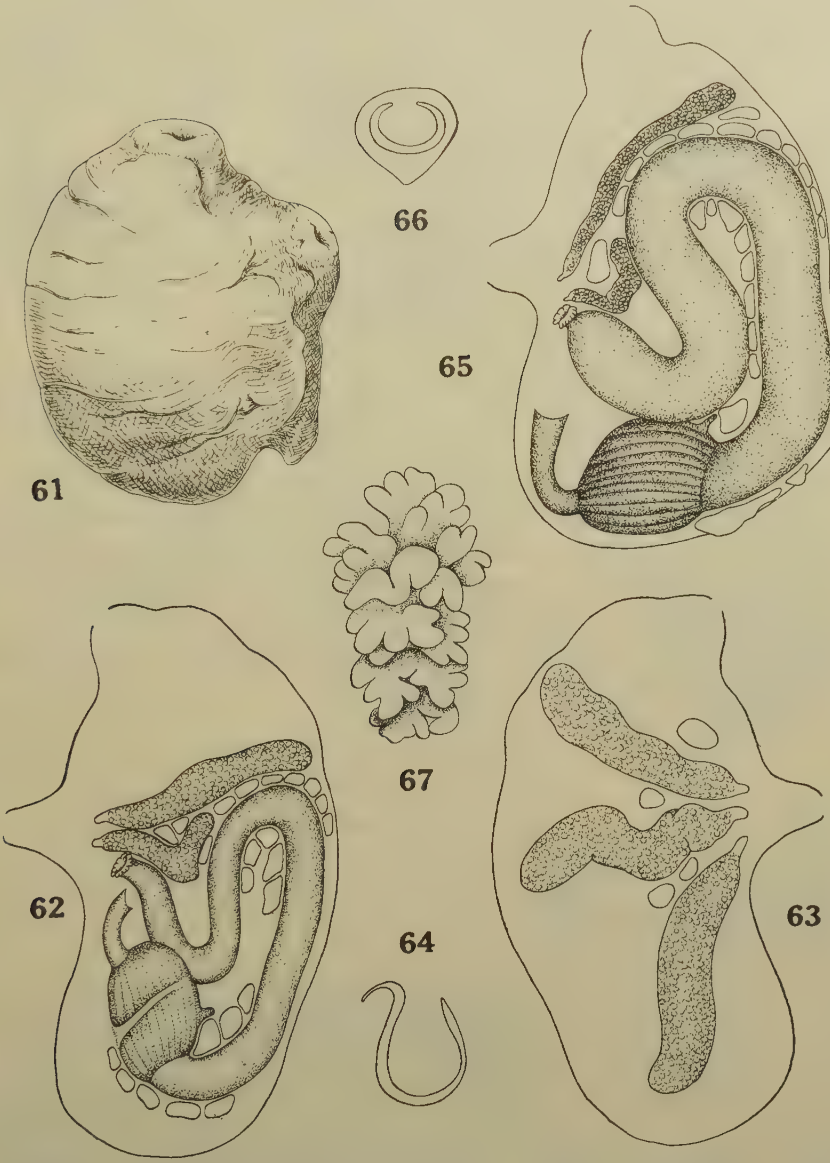


Fig. 12. *Cnemidocarpa areolata* (HELLER). 61—A 23 mm long specimen, left side; 62—Left half of the mantle body of the same individual, inner side; 63—Right half of the same mantle body, inner side; 64—Ciliated groove of the same individual, 65—Left half of the mantle body of a 14 mm long individual, inner side; 66—Ciliated groove of the same individual, 67—Swelling of the subneural gland of a 15 mm long individual, enlarged.

Three thinner transverse vessels are found between each pair of thicker ones, parastigmatic vessels are mostly found in the posterior part of the sac. Five to seven stigmata in each mesh, but they may be up to 9 in larger meshes along the endostyle. Tentacles 21–24 in examined specimens, the order of the arrangement is 1 3 2 3 1, here the numerals indicate the orders of the thickness. Ciliated groove is simply U or C–shaped opened anteriorly.

Alimentary system: The anterior end of the intestinal loop reaches the level of the base of the atrial siphon or beyond it to the middle of the range between both siphons. The second loop is very distinct, its axis passes through the pyloric portion of the small globular stomach which is longitudinally plicated (with about a dozen plications on the free right surface) and with a tiny pyloric coecum. The anal margin is cut into ca. 15 lobules.

Gonad: Three elongate gonads on the right and two on the left. The left posterior gonad never proceeds into the second intestinal loop and this feature differs distinctly from that found in *Styela plicata*.

Remarks: *Cnemidocarpa valborg* HARTMEYER 1919 and *Cnemidocarpa irma* HARTMEYER & MICHAELSEN 1928 are evidently considered to be identical with the present species. The existence of only three gonads on the right side is common to the present specimens, the Palao specimens described by TOKIOKA (1950) and those described by KOTT (1952). However, the occurrence of fewer gonads may be attributable to the smallness of those specimens rather than to be regarded as a characteristic of some taxonomic significance.

12. *Styela partita* (STIMPSON), 1852

(Text-fig. 13, Table 1)

?*Styela rectangularis*—KOTT, P. (1952): The Ascidians of Australia I. Stolidobranchiata LAHILLE and Phlebobranchiata LAHILLE. Australian Jour. Mar. Freshwater Res., Vol. 3, No. 3, pp. 224–226, text-figs. 27–29.

In all 104 specimens in the material; they range from 2 mm to 17 mm in body length, but most frequently 6–12 mm. The body shape varies considerably, some are erect, ellipsoidal and attached to the substratum by the left posterior part of the body, while others are roughly globular or ellipsoidal and lying with the whole ventral side beneath. The branchial aperture is usually terminal in the erected ellipsoidal or globular individuals, but rather subterminal in lying individuals. The situation of the atrial siphon varies from the middle of the body to the level of the anterior one third. Both apertures nearly sessile and siphons are quite short in the preserved specimens. The test is leathery, yellowish brown or reddish brown on the surface, being somewhat darker on the dorsal side, but whitish on the inner surface. It is rather thick and about 0.5 mm in thickness in contracted specimens, but very thin in extended ones. The surface is nearly

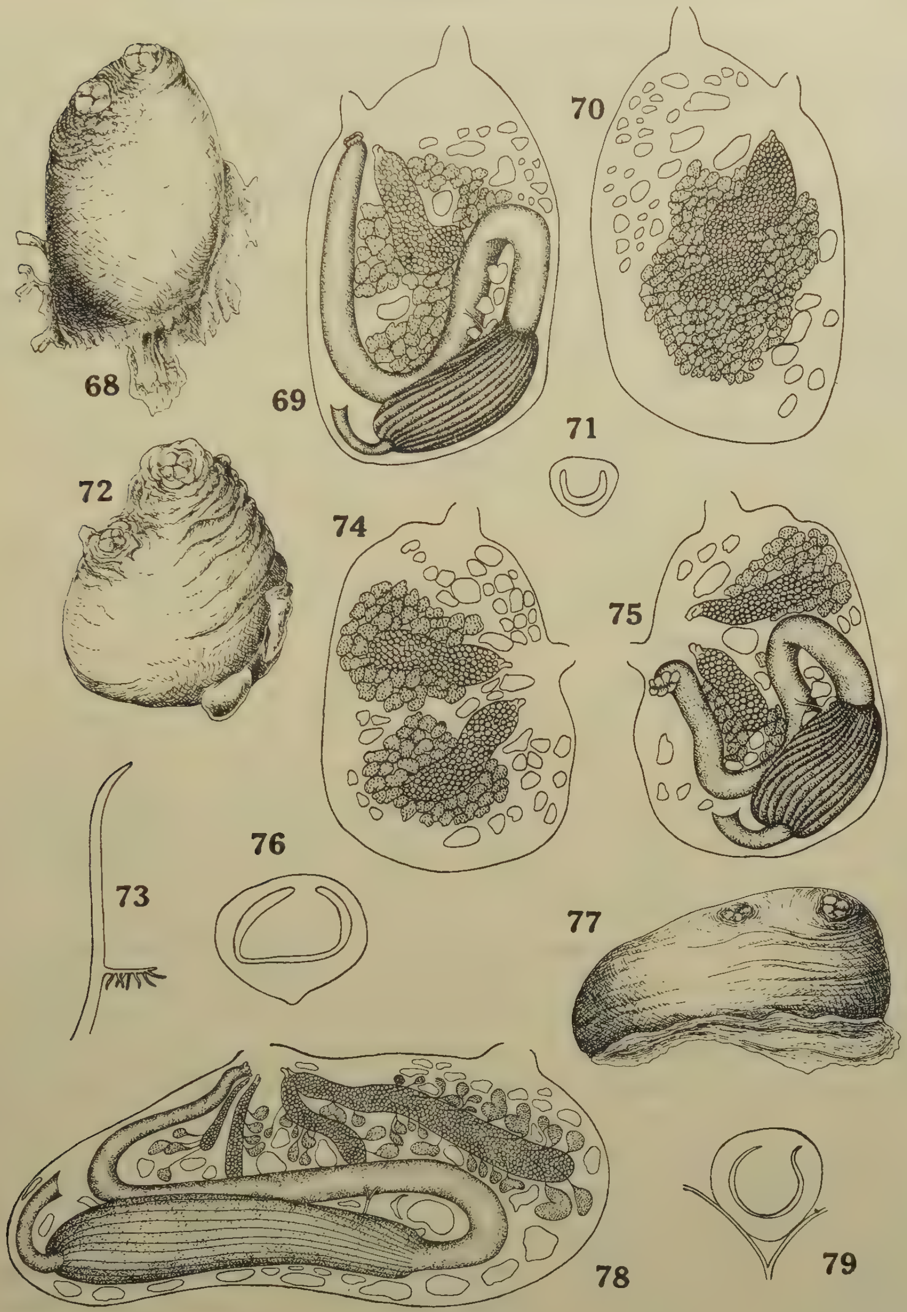


Fig. 13. *Styela partita* (Stimpson). 68—A 14 mm long individual, 69—Left half of the mantle body of the same individual, inner side; 70—Right half of the same mantle body, inner side; 71—Ciliated groove of the same individual, 72—A 13 mm long individual, 73—Schema of the optical section of the wall of the atrial siphon, showing the villose atrial velum, 74—Right half of the mantle body of the same individual, inner side; 75—Left half of the same mantle body, inner side; 76—Ciliated groove of the same individual; 77—The 13 mm long elongate lying specimen, 78—Left half of the mantle boody of the same individual, inner side; 79—Ciliated groove of the same individual.

smooth in extended specimens, but wrinkled or irregularly corrugate in contracted ones. The mantle is light reddish brown or purplish brown in colour, usually darker on the dorsal side and varies in thickness according to the state of contraction. The inner surface of the atrial velum is densely set with fine tentacular prominences (text-fig. 13, *73*). Many endocarps are scattered on the inner surface on both sides.

Branchial sac: The tentacles are fundamentally composed of 8 large, 8 medium and 16 small or minute ones, thus 32 in all, arranged in the order of large-small-medium-small-large. The ciliated groove is C-shaped opened anteriorly. Inner longitudinal vessels are arranged as:

13 mm long specimen										
Left	D.	2	(11)	2	(10)	2	(13)	2	(10)	1	V.
Right	D.	3	(13)	2	(10)	2	(12)	2	(9)	1	V.
13 mm long specimen											
Left	D.	3	(14)	3	(12)	3	(12)	3	(9)	2	V.
Right	D.	3	(16)	2	(13)	3	(14)	3	(10)	2	V.
14 mm long specimen											
Left	D.	2	(12)	3	(9)	2	(13)	2	(8)	2	V.
Right	D.	4	(12)	3	(10)	3	(10)	3	(8)	1	V.

Thicker and thinner transverse vessels alternate regularly or they are found arranged in the order of 1 3 2 3 1, the numerals indicate the orders of the thickness; parastigmatic vessels are usually found in the posterior part of the sac. Four to seven very elongate stigmata in each mesh, they may be up to 12 in larger ones along the endostyle.

Alimentary system: The intestinal loop is very prominent and with the very distinct second loop, the axis of which passes through the cardiac end of the stomach or the oesophageal region. The stomach is elongate, marked with 10–12 longitudinal plications on the right free surface and has a minute pyloric coecum. The length of the stomach is always larger than one half of the ventral branch of the intestinal loop. The whole alimentary canal is relatively short in globular or erected ellipsoidal individuals, and consequently the stomach is not so long, while the whole canal is generally very long and the stomach is also extremely elongate in those which are lying along the ventral side (text-fig. 13, *78*). In the latter, the vessel connecting the inner pyloric part of the stomach with the intestine is issued from the level fairly in front of the coecum, this vessel is generally issued from the anterior base of the coecum on shorter stomachs. The anal margin is cut into 8–10 lobules.

Gonad: Usually two gonads on each side. Ovaries are elongate and testes are spread around the ovaries. Rarely one or both gonads are missing on one or

Table 1. *Styela partita* (STIMPSON) Occurrences of various numbers of gonads in the present material.

Number of gonads / Body length	Left 4 Right 2	Left 2 Right 2	Left 2 Right 1	Left 2 Right 0	Left 1 Right 2	Left 1 Right 1	Left 0 Right 2	Left 0 Right 1	Left 0 Right 0	Mutilated	Total
17 mm		1			1						2
16		2									2
15		5									5
14		2				1					3
13	1	4									5
12		14								1	15
11		8	1								9
10		10	1		1		1			1	14
9		16	1	1							18
8		9									9
7		5			2				1		8
6		5							1	1	7
5		2						1			3
4		1						1			2
3		1									1
2									1		1
Total	1	85	3	1	4	1	1	2	3	3	104

both sides as seen in Table 1. The most strange is the 13 mm long elongate individual shown in text-fig. 13, *78*; this is provided with four gonads on the left side, the anterior two of them are united into one near the apertures. At a glance on the internal structure of this specimen, I thought immediately of *Cnemidocarpa macrogastra* (Oka) and *Cnemidocarpa personata* (Herdman), because it was provided with four gonads and a very elogate stomach on the left side. However, the details of the structure are exactly the same as those of other specimens and every extreme feature, exclusive of gonads, is quite continuous to the ordinary one. The existence of four gonads must be a remarkable abnormality.

In most of individuals less than 5 mm gonads are still immature, although a 3 mm long individual was found with semimatured gonads in which the testes were coloured red and one of the 5 mm long individuals was found fully matured. Contrarily, a single 12 mm long individual was found with only rudimentary gonads.

Remarks: *S. rectangularis* Kott 1952 conforms very well to the present species in every detail. It is not impossible that both species are quite identical with each other.

13. *Herdmania momus* (Savigny), 1816

(Text-fig. 14)

Thirty-four specimens in all, they are 5–49 mm in length and those smaller than 8 mm long are not yet provided with any gonads. The test is soft cartilaginous, but tough enough; it is usually 1–1.5 mm thick in larger specimens, but up to 3 mm at some posterior portions. The surface is originally smooth, but becomes wrinkled or grooved by contraction, and sometimes it is covered with the nest tubes of polychaetes and hydrozoan colonies. The surface is pale grayish brown. The mantle is light grayish purple with a reddish tint at the tip of siphons in fresh specimens, but the colouration fades to light reddish brown with time. The consistency is rather soft. Large spicules attain 1 mm in length. The anterior end of the intestinal loop reaches near the anterior end of the body. The axis of the second intestinal loop passes through approximately the distal end of the gastric region. The anal margin is plain. Eight plications, eight and one rudimentary plications or nine ones on each side of the branchial sac. Eighteen large and medium-sized tentacles are found in a dissected 43 mm long individual; besides, one or two small ones are present at intervals; branches in 3 orders. The ciliated groove is rosette-formed in all examined specimens. Thus, all of the present specimens seem to belong to the ordinary shallow water form of the species and none of the variety *grandis* (Heller) characteristic to Australian waters was found in the material.

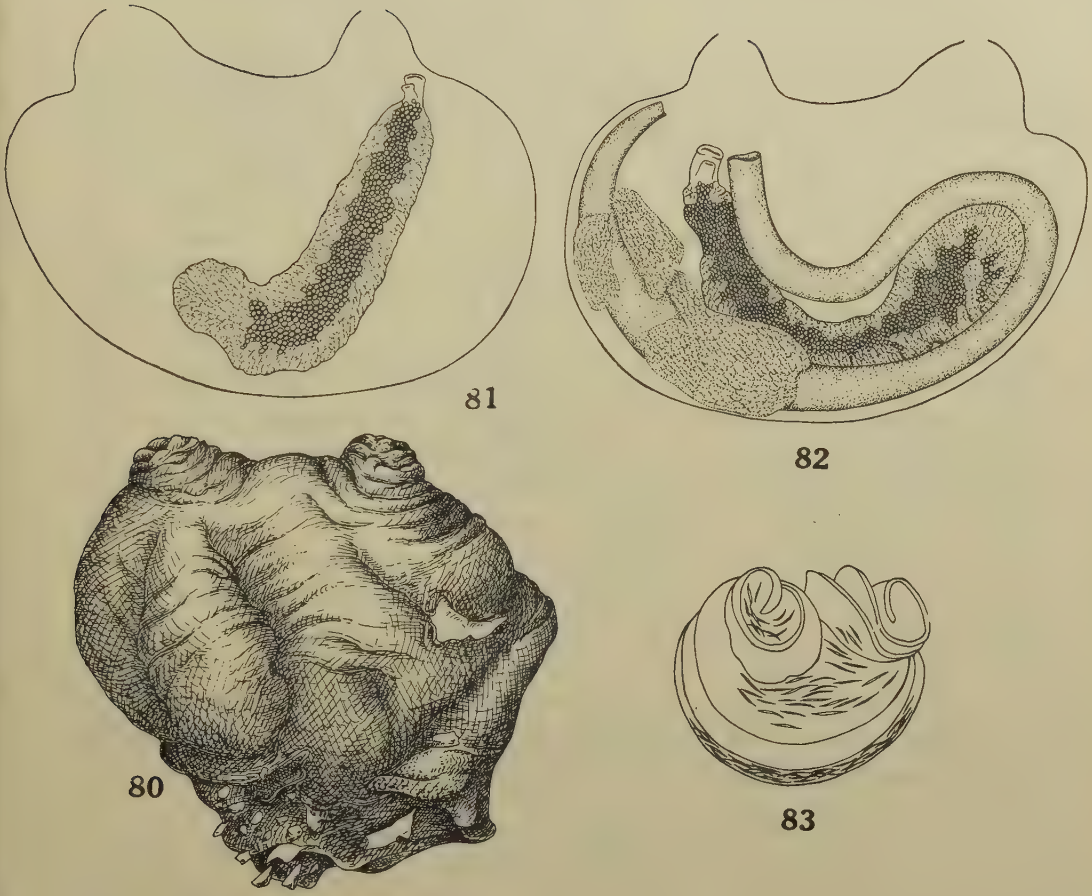


Fig. 14. *Herdmania momus* (SAVIGNY). 80—A 43 mm long specimen, 81—Right half of the mantle body of the same individual, inner side; 82—Left half of the same mantle body, inner side; 83—Ciliated groove of the same individual.

14. *Microcosmus* sp. aff. *multiplicatus* TOKIOKA, 1952

(Pl. V, fig. 5; Text-fig. 15)

TOKIOKA, T. (1952): Ascidans collected by Messrs. RENZI WADA and SEIZI WADA from the pearl-oyster bed in the Arafura Sea in 1940. Publ. Seto Mar. Biol. Lab., Vol. 2, No. 2, pp. 132–134, text-fig. 26.

Eight 19 to 32 mm long specimens in the collection. The body is roughly ovoid and attached to the substratum by the ventral, postero-ventral or left postero-ventral side. The branchial siphon is terminal and the atrial is situated approximately at the middle of the dorsal side, both siphons are strongly contracted in preserved specimens. The test is hard leathery, very tough and up to 1 mm thick on the dorsal side, but very thin on the attachment surface. It is usually pinkish brown or reddish brown, although rarely it may be yellowish brown. Originally the surface is smooth, but wrinkled or irregularly corrugate by contraction and may carry mud or some foreign materials on some parts. The siphons are, however, always strongly corrugate and coloured darkly. The inner surface is lighter in colouration. The inner surface of the distal part of both branchial and atrial siphons is armed densely with minute conical spinules, 30–45μ in length, while that of the proximal part is very soft and furnished rather sparsely with very fine tentacular prominences, about 260μ in length (text-fig. 15, *88*). The mantle is of a moderate thickness and furnished with a well-developed musculature, it is dark brownish red or reddish brown and with a purplish hue. The mantle adheres very firmly to the soft somewhat gelatinous inner layer of the test.

Branchial sac: Tentacles 16 when the larger and medium-sized ones are counted; besides, a smaller one at each interval; branches in 2 or 3 orders, those of the third order are very scarce. Branchial plications are:

19 mm long individual	left 9	right 10
20	10	10
21	9	11
26	9	10
27	9	10
27	9	9
32	10	12
32	10	11

One or two ventral ones are rudimentary and defined only in the anterior part of the sac. Inner longitudinal vessels are:

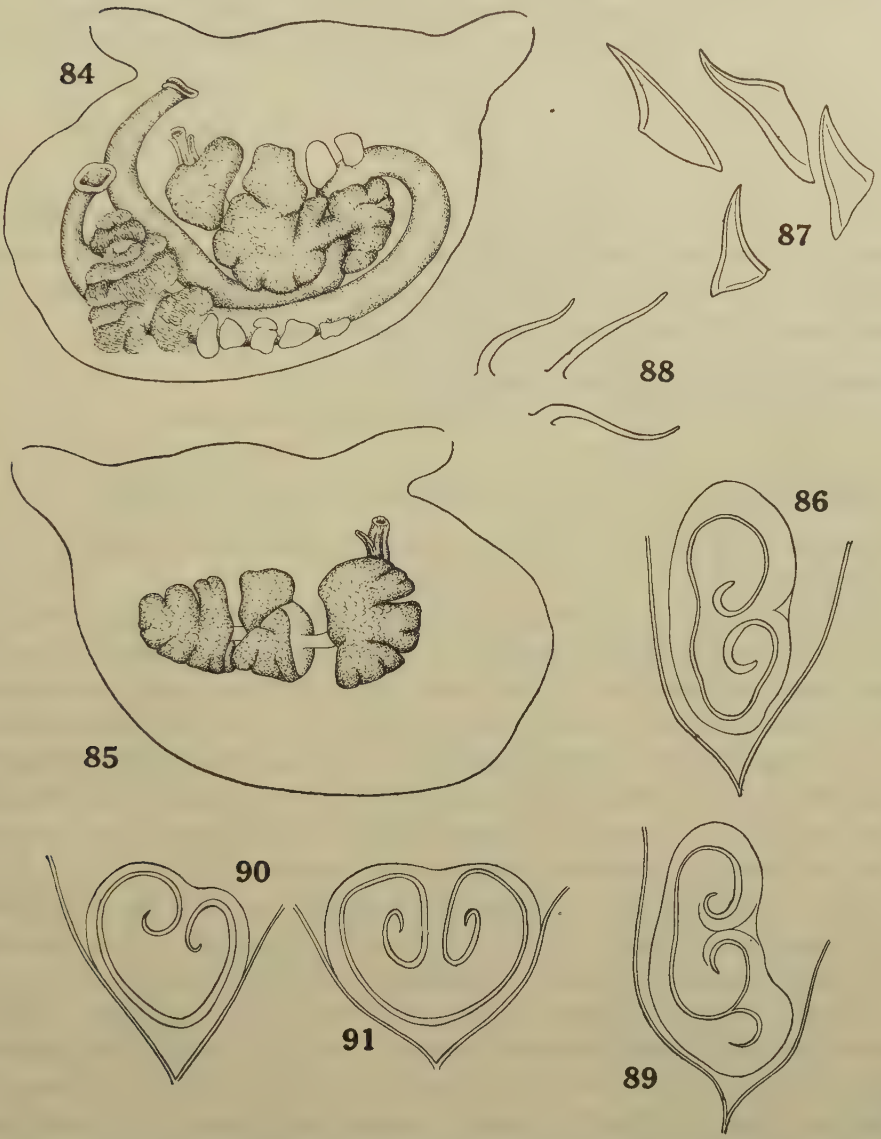


Fig. 15. *Microcosmus* sp. aff. *multiplicatus* Tokioka. 84—Left half of the mantle body of a 32 mm long individual, inner side; 85—Right half of the same mantle body, inner side; 86—Ciliated groove of the same individual, 87—Spinules on the distal part of the stomodaeum, ×440; 88—Filamentary prominences on the inner part of the stomodaeum, ×73; 89—Ciliated groove of another 32 mm long individual, 90—Ciliated groove of a 27 mm long individual, 91—Ciliated groove of a 26 mm long individual.

the last one of the above list

Left D. 3 (24) 4 (24) 3 (32) 4 (28) 4 (26)
4 (25) 3 (22) 1 (17) 1 (17) 1 (12)
0 V.
Right D. 3 (23) 2 (25) 3 (30) 4 (28) 4 (28)
3 (27) 3 (25) 1 (22) 1 (21) 1 (18)
1 (13) 1 V.

Transverse vessels are arranged partly in the order of 1 4 3 4 2 4 3 4 1, here the numerals indicate the orders of the thickness, parastigmatic vessels present. Stigmata are rather small and usually 3–4 ones are found in each mesh. The ciliated groove is C-shaped with both horns incurled, it is opend

anteriorly in one individual (26 mm long),
obliquely in five individuals (19, 20, 21, 27, and 27 mm long),
and
laterally towards the right in two individuals (both 32 mm long).

This feature reminds us of that found in *Microcosmus hartmeyeri* Oka in the Japanease waters.

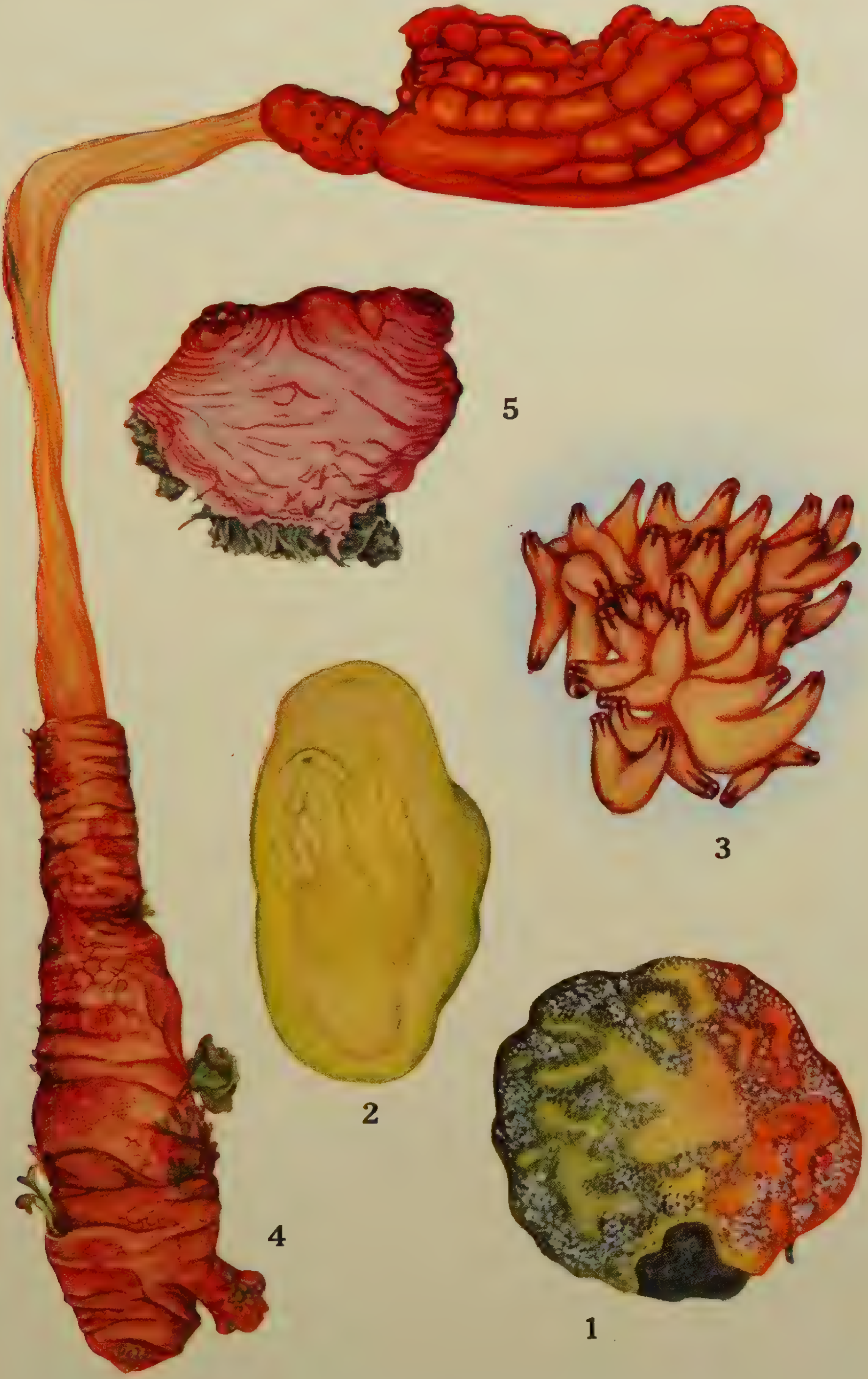
Alimentary system: The bottom of the second intestinal loop touches the middle of the vental branch of the first loop, the position fairly posterior to the gastric region furnished with hepatic lobes. Liver is orange brown or yellowish brown in colour, hepatic lobules are each provided with several minute papillae. The anal margin is plain. Several endocarps are arranged in a row on the ventral wall of the proximal portion of the intestine and a few ones on the dorsal wall of the proximal part of the dorsal branch of the loop and also on the intestinal wall at the bottom of the second loop in some specimens.

Gonad: A single gonad on each side, it consists of three genital capsules and the anterior-most capsule of the left gonad is located in the first intestinal loop. The 20 mm long specimen is devoid of gonad on the right side.

Remarks: These specimens are provided with rather numerous branchial plications and this feature resembles closely that of *M. multiplicatus* Tokioka described on a single specimen from the Arafura Sea. On the other hand, *M. multiplicatus* itself and also the present specimens are related very closely with *M. exasperatus* Heller occurring very commonly in the tropical Pacific waters which is usually provided with 7–9 branchial plications on each side. Indeed, the gap found in the number of branchial plications is the only distinct clue separating *M. multiplicatus* and *M. exasperatus* from each other. At present, it is very hard to find out whether the number of plications is quite continuous between these two species or there are two distinctly different modes when the number of plications is examined on a number of specimens of these two species collected at various localities. For this reason, it is practically impossible to decide right now the validity of *M. multiplicatus* and thus the present specimens are treated provisionally as the form affined to *M. multiplicatus.*

EXPLANATION OF PLATE V

1···*Polyclinum constellatum* SAVIGNY, a colony with a 45 mm diameter; two colour types are shown on the same colony.
2···*Phallusia julinea* SLUITER, the 51 mm long specimen.
3···*Polyandrocarpa* (*Polyandrocarpa*) *rollandi* n. sp., the living 70 mm × 50 mm colony.
4···*Polycarpa aurata* f. *clavata* HARTMEYER, the living 85 mm long (trunk length) individual with the peduncle 352 mm in length.
5···*Microcosmus* sp. aff. *multiplicatus* TOKIOKA, the 32 mm long specimen.



T. TOKIOKA: ASCIDIANS COLLECTED DURING THE MELANESIA EXPEDITION, I

THE PELAGIC COPEPODS OF THE IZU REGION, MIDDLE JAPAN SYSTEMATIC ACCOUNT VII[1]

FAMILY SCOLECITHRICIDAE (PART 1)

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With 21 Text-figures

Family SCOLECITHRICIDAE

The family Scolecithricidae comprises, at present, nine genera, namely, they are *Scottcalanus* SARS, *Scolecocalanus* FARRAN, *Macandrewella* A. SCOTT, *Lophothrix* GIESBREGHT, *Scaphocalanus* SARS, *Scolecithrix* BRADY, *Scolecithricella* SARS, *Amallothrix* SARS and *Racovitzanus* GIESBRECHT.

In these genera the 1st maxilla has in general the following numbers of setae on the various parts, viz. 9 setae (sometimes 11 or 8) on the outer lobe, 9 setae (sometimes 8, 7, or 5) on the exopod, 7 setae (sometimes 10, 8, or 6) on the endopod, 5 (sometimes 4 or 3) setae on the 2nd basal joint, 4 setae (sometimes 3) on the 1st inner lobe, 2 setae on the 2nd inner lobe, and 12 (sometimes 13, 10, 9 or 8) setae on the 1st inner lobe. The 2nd maxilla is furnished with sensory appendages on the endopod, which are either all vermi-form or some of them bud-like. The 1st leg has 3-jointed exopod and unjointed endopod. The 1st joint of the exopod of the 1st leg has an outer edge spine in the following genera: *Scottcalanus*, *Macandrewella* and *Amallothrix*. But it is wanting in the remaining genera, with the exception of a species of *Scolecithricella*, *S. ovata* (FARRAN). The 2nd to 4th legs are spinulose on the posterior surface of the endopod and exopod. The 5th pair of legs of the female is sometimes wanting, but in most cases present, though it is simple in structure.

SARS (1925) created a genus *Amallothrix* which had been comprised in the genus *Scolecithricella*. Some authors have accepted the genus *Amallothrix*, some have rejected it on account of the difficulties met with in the discrimination of both genera using the characters of the 2nd maxilla and 5th legs given by SARS.

All of the genera except *Macandrewella* and *Scolecocalanus* were found in the

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1) Part VI appeared in this journal, Vol. VIII, No. 1, pp. 85–135 (1960).

Publ. Seto Mar. Biol. Lab., IX (1), 1961. (Article 9)

collection. In addition to the genera mentioned above a new genus *Undinothrix* will be proposed, which is very closely allied to *Lophothrix*.

Genus *Scottcalanus* G. O. SARS

Nine species of the genus *Scottcalanus* have been reported from the Malayan and Indian Seas: *Scottcalanus securifrons* (T. SCOTT), *S. helenae* (LUBBOCK), *S. persecans* (GIESBRECHT), *S. farrani* A. SCOTT, *S. setosus* A. SCOTT, *S. longispinus* A. SCOTT, *S. thomasi* A. SCOTT, *S. investigatoris* SEWELL, and *S. dauglishi* SEWELL. FARRAN recorded *S. longispinus* A. SCOTT, *S. sedatus* FARRAN, *S. australis* FARRAN from the Great Barrier Reef region. From the Arabian Sea SEWELL has recorded *S. dauglishi* SEWELL, *S. helenae* (LUBBOCK), *S. persecans* (GIESBRECHT), and *S. securifrons* (T. SCOTT). In the present collection I have found *S. securifrons*, *S. helenae*, *S. australis* and *S. rotundatus*. The last species appears to have been undescribed.

The typical species of the genus, *S. securifrons*, was first obtained by T. SCOTT in the plankton collected from the Gulf of Guinea. He described both female and male. But his male specimen really belongs to another species, *Undina helenae* LUBBOCK. In 1895 GIESBRECHT described a species closely related to *S. securifrons* under the name *S. persecans* by the male specimen taken from the Pacific Ocean. Since then a good deal of confusion have arisen in the identification of these two species, *S. helenae* and *S. persecans*. FARRAN (1908) described both female and male of a species of *Scottcalanus* believing to be identical with *S. persecans*. A. SCOTT described and figured *S. helenae* and *S. persecans* and several other species of *Scottcalanus* and concluded that the male of *persecans* described by FARRAN was not identical with *persecans* (GIESBRECHT) but identical with *helenae*, and the female of *persecans* required further verification as to its correctness of the identity with GIESBRECHT's species. WITH (1915) proposed a new name, *S. thorii*, to the Atlantic species of *S. persecans* which had been recorded by FARRAN from the Atlantic. SARS (1925) described and figured the female and male of *S. persecans* and concluded that *S. thorii* is a synonym of *S. persecans* GIESBRECHT. SEWELL (1929) is of opinion that *S. thorii* is identical with the form recorded by FARRAN under the name *persecans* from the Irish coast, but is different from *S. persecans* (GIESBRECHT), and SARS is erroneous in regarding *S. persecans* and *S. thorii* as synonymous. According to SEWELL (1947, 1929) *S. thorii* is identical with *S. helenae* (LUBBOCK) described and figured by A. SCOTT. I have found in my collection 22 male speciemens of *S. helenae*. My form agrees quite well with the description and figures of *S. helenae* given by A. SCOTT. He illustrated on the same plate (pl. XXVII) the male of *S. persecans* (GIESBRECHT). The main differences between these two males are in the shape of the rostrum and in the length of the endopod of the left 5th leg. The endopod of the left 5th leg is short and clumsy in *S. helenae*, whereas, it is longer and slender in *persecans*.

This long endopod is clearly illustrated also by Esterly (1905, p. 166, fig. 28, c). When comparing these figures of the 5th legs given by A. Scott and Esterly with those of *thorii* (With, 1915, pl. VIII, fig. 14, a, b) we find a similarity in the proportional lengths of the endopod of the left 5th leg. I think *S. thorii* is, so far as the male is concerned, a synonym of *S. persecans* (Giesbrecht), and is not the synonym of *S. helenae* (Lubbock).

Scottcalanus securifrons (T. Scott)

(Fig. 106, a–e)

Scottcalanus securifrons, T. Scott, 1893, p.47 (female); A. Scott, 1909, p.104, pl. 25, figs. 1–9, pl. 28, figs. 1–9; With, 1915, p. 220, text-figs. 71–73; Sars, 1925, p. 160, pl. 45, figs. 1–8; Farran, 1926, p. 267; 1929, p. 251; Tanaka, 1937, p. 259, text-fig. 9, a–c; Sewell, 1947, p. 143; Brodsky, 1950, p. 242, text-fig. 152; *Scottcalanus* sp. Brodsky, 1950, p. 243, text-fig. 153; *Scottcalanus securifrons*, Wilson, 1950, p. 340.

Female. Length, 4.29 mm: cephalothorax, 3.45 mm; abdomen, 0.75 mm. The head fused with the 1st thoracic segment. The 4th thoracic segment fused with the 5th. The head has a high median crest. The last thoracic segment produced posteriorly into triangular expansions with a sharp point at the apex. The distal lateral margin of the last thoracic segment not so outwardly curved as figured by A. Scott or by Sars. The rostrum bifurcate, with a very minute spine at the apex.

The abdomen 4-segmented. The proportional lengths of the segments and furca are as follows: 64:14:5:3:14=100. The genital segment swollen distally in dorsal aspect; the ventral surface of the segment swollen at the middle section; the distal ventral margin of the segment overlaps the following segment; the lateral distal margin of the segment is furnished with rows of spinules on either side, but absent on the distal dorsal and ventral surfaces. The distal margin of the 2nd and 3rd segments are furnished with denticles. The anal segment is very short, almost concealed beneath the preceding. The furcal rami about as long as wide, furnished with ordinary 4 setae and a small seta.

The 1st antenna extends to the distal margin of the furca. The joints are in the following proportional lengths:

Joint	1	2	3	4	5	6	7	8–9	10	11	12	13	14	15	16
	51	44	29	24	29	27	32	63	24	32	41	51	51	51	51

	17	18	19	20	21	22	23	24–25
	49	51	51	49	49	46	49	46 =1000 (left side).

The 2nd antenna has the exopod about 1.4 tiems as long as the endopod (61:43). In the mandible the exopod is longer than the endopod (15:12); the cutting blade has 8 teeth. The 1st maxilla has the following numbers of setae on the various parts: 9 setae on the outer lobe; 8 setae on the exopod; 7 setae on the 2nd basal; 3 setae on the 3rd inner lobe; 2 setae on the 2nd inner lobe; 12 setae on the 1st inner lobe. The 2nd maxilla has on the endopod 2 small bud-like, and 6 long vermi-form filaments: the 5th lobe has a long spine, a ordinary seta, and 2 vermi-from filaments; the 4th, 3rd, and 2nd lobe has each 3 setae; the 1st lobe has 4 setae. The maxilliped has 3 sensory filaments, of which one is short and bud-like, on the 1st basal joint.

The 1st leg has 3-jointed exopod and 1-jointed endopod. The outer edge spine of the joints of the exopod is fairly long. The distal outer margin of the 1st basal joint ends in a broadly rounded process. The 2nd leg has 3-jointed exopod and 2-jointed endopod. The 1st basal joint has a small spine on the outer margin about the middle of the joint. The 2nd basal joint has a sharp spine on the inner distal corner. The 2nd and 3rd joints of the exopod are furnished with coronas of spinules on the posterior surface. The 2nd joint of the endopod has several scattered long spinules on the posterior surface; the anterior surface of the 2nd joint of the endopod has 2 spinules along the mid-line of the joint.

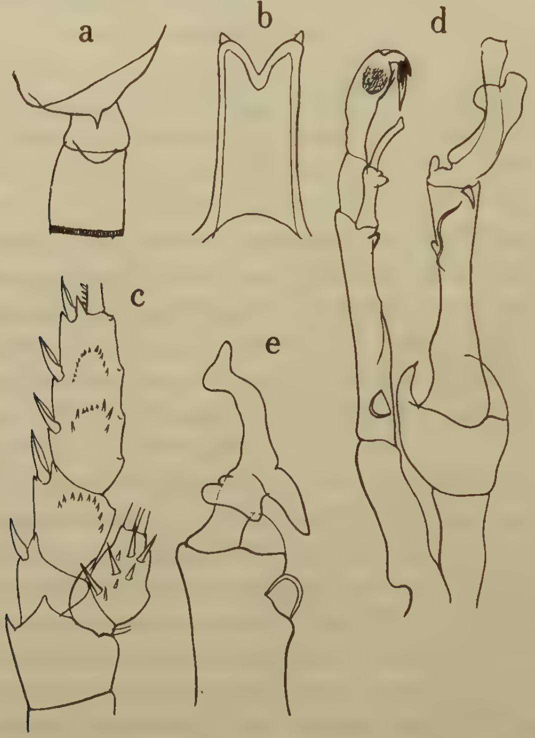

Fig. 106. *Scottcalanus securifrons* (T. SCOTT).
Male: a, last thoracic segment, lateral aspect; b, rostrum; c, 2nd leg, posterior aspect; d, 5th pair of legs; e, distal segments of right 5th leg.

The 3rd leg has 3-jointed exopod and endopod. The 2nd and 3rd joints of the endopod are furnished with spinules on the posterior as well as on the anterior surfaces The terminal spine of the exopod has 27 serrations. The 4th leg has no marginal spine on the 1st basal joint. The 2nd and 3rd joints of the endopod have each small spines on the anterior surface.

The 5th pair of legs asymmetrical. The subapical spine of the left leg is thicker than that of the right. The subapical spine has 2 rows of denticles which diminish in size distally. The apical spine is about 1/3 the length of the 2nd joint.

Male. Length, 4.81 mm : cephalothorax, 3.56 mm ; abdomen, 1.25 mm. General appearance as in the female. The last thoracic segment terminates one each side into a small spine at the apex (fig. a). The abomen 5-segmented ; the segments and furca are in the proportional lengths : 15 : 29 : 21 : 19 : 6 : 10 – 100. The 2nd to 4th segments are striated with fine teeth on the distal margin.

The 1st antenna extends to the distal end of the 3rd abdominal segment. The joints 8–9, joints 20–21 are fused on the left side. The mouth parts and swimming legs as those of the female.

The 5th pair of legs (fig. d, e) as figured by A. SCOTT, but the small teeth on the inner margin of the proximal joint of the endopod of the left leg were not observed in the present specimen.

Remarks. The female of *S. securifrons* is easily recognised by the shape of the last thoracic segment and the genital segment which partially overlaps the 2nd abdominal segment, and by the asymmetrical 5th pair of legs. SARS recorded the occurrence of *S. securifrons* from the Atlantic. His description is right, but his figure of the female 5th pair of legs appears to be different from those figured by A. SCOTT. SARS' specimen has 3-jointed 5th legs ; the distal joint has a very small spine at the base of the apical spine the subapical spine is symmetrical and bifid at the apex as is found in those of *S. australis* FARRAN. BRODSKY'S figure of *S. securifrons* is not his original one, but reproduced from SARS' (1925).

Occurrence. The species is very common in the deep waters of the Izu region.

Distribution. The species has a fairly wide distribution, and has been recorded from the Atlantic, Pacific, and Indian Oceans. Also recorded from the Malay Archipelago, Arabian Sea, Far-eastern and Polar Seas of the U.S.S.R., and Izu region, the Pacific Coast of Middle Japan.

Scottcalanus helenae (LUBBOCK)

(Fig. 107, a–j)

Scottcalanus securifrons, T. SCOTT, 1894, p. 47, pl. 4 (male) ; *Undina helenae*, GIESBRECHT und SCHMELL, 1898, p. 52 (male) ; *Scottcalanus helenae*, A. SCOTT, 1909, p. 111, pl. 27, figs. 1–9 (male) ; *Scottcalanus helenae*, SEWELL, 1929, p. 188 ; 1947, p. 143 ; WILSON, 1950, p. 338, pl. 36, figs. 543–546.

Female. Length, 4.40 mm : cephalothorax, 3.50 mm ; abdomen, 0.90 mm. The head fused with the 1st thoracic segment. The 4th thoracic segment incompletely separates from the 5th. The median crest of the head high (fig. a). The lateral corner of the last thoracic segment produced triangularly with a point at the apex (fig. b). The length of the rostral spines is shorter than half the depth of the excavation (fig. d).

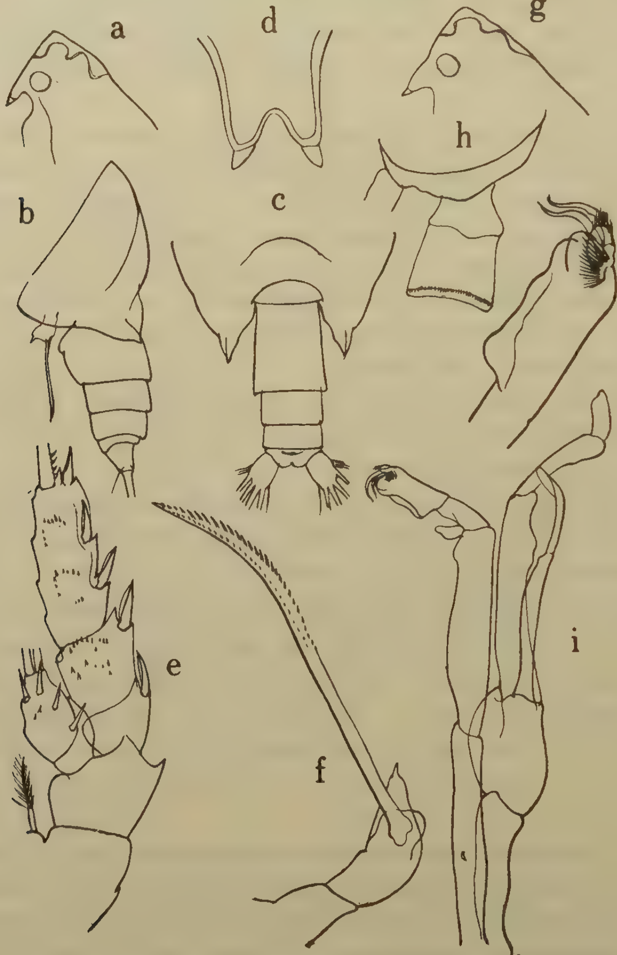

Fig. 107. *Scottcalanus helenae* (LUBBOCK).
Female : a, head, lateral aspect ; b, last thoracic segment and abdomen, lateral aspect ; c, last thoracic segment and abdomen, dorsal aspect ; d, rostrum ; e, 2nd leg ; f, 5th leg. Male : g, head, lateral aspect ; h, last thoracic segment, lateral aspect ; i, 5th pair of legs ; j, distal joint of left 5th leg.

The abdomen 4-segmented ; the segments and furca are in the proportional lengths, 46 : 20 : 11 : 6 : 17=100. The genital gegment clyndrical in dorsal view, about 2 times as long as wide (fig. c) ; the ventral surface produced below with a process on the proximal part near the genital orifice when viewed from the lateral. The furcal rami about as long as wide (15 : 14).

The 1st antenna 24-jointed, extends to the distal margin of the anal segment ; the joints 8-9 are partially fused with the joint 10 ; the joints 24 and 25 are well separated. The 2nd antenna has the exopod 1.4 times as long as the endopod (37 : 26). The mandible, maxillae, and maxilliped as those of *S. securifrons* (T. SCOTT).

The swimming legs as those of *S. securifrons.* The terminal spine of the exopod of the 2nd to 4th legs have each 25, 26 and 27 teeth respectively.

The 5th pair of legs 2-jointed, reaches back to the distal margin of the 2nd abdominal segment. The 2nd joint swollen at the middle section. The subapical spine is about 3 times the length of the 2nd joint, and is furnished with two rather coarse spines. The basal part of the spine is swollen. The apical spine is short and fine, slightly curved outwardly (fig. f).

Male. Length, 4.5 mm : cephalothorax, 3.2 mm ; abdomen, 1.25 mm. The male resembles the female in appearance, but the last thoracic segment rather broadly rounded ; the ventral margin of the segment much inflated when viewed from the side (fig. g, h).

The abdomen 5-segmented ; the segments and furca are in the proportional lengths, 18 : 24 : 23 : 21 : 7 : 7=100. The distal margin of the 2nd to 4th segments are fringed with fine teeth.

The 1st antenna extends to the middle of the 4th abdominal segment. The mouth parts and the 1st to 4th swimming legs as those of the female. The serration on the terminal spine of the exopod of the 2nd to 4th legs are more in number than those of the corresponding legs of the female.

In the 5th pair of legs (fig. i) the endopod of the right leg is long and curved towards the exopod, reaching about to the middle of the 2nd joint of the exopod. The endopod of the left leg is short, about half the length of the 1st joint of the exopod of the same leg. The 2nd joint of the exopod of the left leg dilated much on the inner margin. The 3rd joint of the exopod is represented by two curved stout spines, a pad of stiff hairs, and a leaf-like lamellous process with serrations on the distal end (fig. i).

Remarks. The present female specimen resembles very closely *S. longispinus* A. SCOTT, but there are some minute points of difference in the form of the genital segment and in the length of the subapical spine of the 5th leg. *S. longispinus* described by FARRAN has the genital segment similar in form to the present specimen. The male specimen agrees well with the description and figures of *S. helenae* given by A. SCOTT. According to FARRAN (1936) the male of *S. longispinus* has the 5th thoracic segment with a small spine at its distal end, and the rostral spine which differs from that of the female. WILSON's specimen of *S. helenae* appears to be identical with the present species. But his male specimen differs from the present male in having angularly pointed corner on the last thoracic segment.

Occurrence. 30 females accompanied with 22 males from the deep waters of the Izu region.

Distribution. The species is widely distributed in the Atlantic, Pacific and Indian Oceans. Also recorded from the Malayan region and from the Arabian Sea.

Scottcalanus australis FARRAN

(Fig. 108, a–f)

Scottcalanus australis, FARRAN, 1936, p. 101, text-fig. 13, a–e.

Female. Length, 3.90 mm : cephalothorax, 3.13 mm ; abdomen, 0.77 mm ; so the abdomen is contained 4.2 times in the length of the cephalothorax. The head is fused with the 1st thoracic segment, and so are the 4th with the 5th (fig. a).

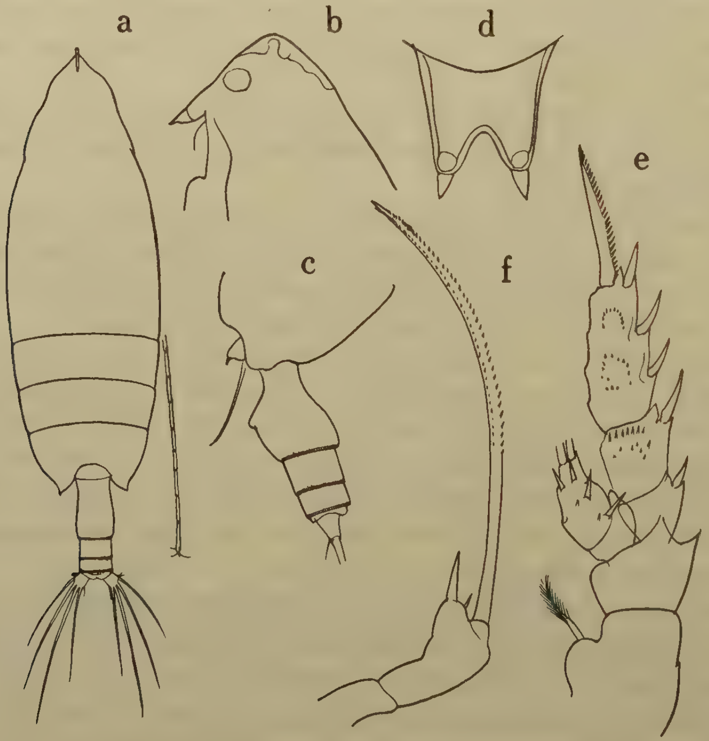

Fig. 108. *Scottcalanus autralis* FARRAN.
Female : a, dorsal aspect ; b, head, lateral aspect ; c, last thoracic segment and abdomen, lateral aspect ; d, rostrum ; e, 2nd leg ; f, 5th leg.

The head has a high median crest (fig. b). The lateral corner of the last thoracic segment narrowly rounded. (fig. c). The rostral spine is half the depth of the excavation. The spine is slightly notched on the posterior margin when viewed from the lateral (fig. d).

The abdomen 4 segmented; the segments and furca are in the proportional lengths, 48 : 17 : 13 : 10 : 12 = 100. The genital segment, when viewed from the side, produced ventrally into a small triangle at the genital orifice. The first three segments are fringed with fine teeth on the distal margin (fig. c).

The 1st antenna 24-jointed, extends to the distal margin of the anal segment.

The mouth parts and 1st to 4th legs are as those of the other members of the genus. The 2nd leg has 26 serrations on the teaminal spine of the exopod (fig. e).

The 5th pair of legs 2-jointed. The terminal joint has an apical spine which is about half as long as the distal joint, and a small spine at the base of the spical spine. The subapical spine is 4 times as long as the distal joint. The spine is bifid at the apex (fig. f).

Remarks. The specimen agrees quite well with the description and figures given by FARRAN. The 5th pair of legs of *S. securifrons* figured by SARS (pl. 45, fig. 5) resembles that of the present species in having a small spine at the base of the apical spine, and in the subapical spine which is furnished with denticles extending more than half the length of the spine.

Occurrence. 3 females from the depth 0–1000 m. in the Izu region, December 1938.

Distribution. The species has been recorded from the deep waters of the Great Barrier Reef of Australia. The occurrence of the species will indicate that the deep water of the Indo-Pacific has, in some extent, an intercommunication with the waters of the North Pacific.

Scottcalanus rotundatus sp. nov.

(Fig. 109, a–k)

Female. Length, 4.07 mm : cephalothorax, 3.8 mm ; abdomen, 0.69 mm ; so the abdomen is contained about 5 times in the length of the cephalothorax. The head is incompletely separates from the thoracic segment; so are the 4th from the 5th (fig. d). The head has no median crest; the frontal margin obtusely rounded when viewed from the lateral (fig. b). The lateral distal corner of the last thoracic segment trinagularly produced, and pointed at the apex (fig. c). The rostral spine is about as long as the depth of the excavation (fig. d).

The abdomen is composed of 4 segment; the segments and furca are in the proportional lengths : 46 : 20 : 14 : 5 : 51 = 100. The genital segment swollen below, and slightly produced on the genital opening in lateral aspect; the lateral margins of the segment are slightly constricted at the distal 1/3 of the segment when viewed from the dorsal. The furcal rami about as long as wide. The first three

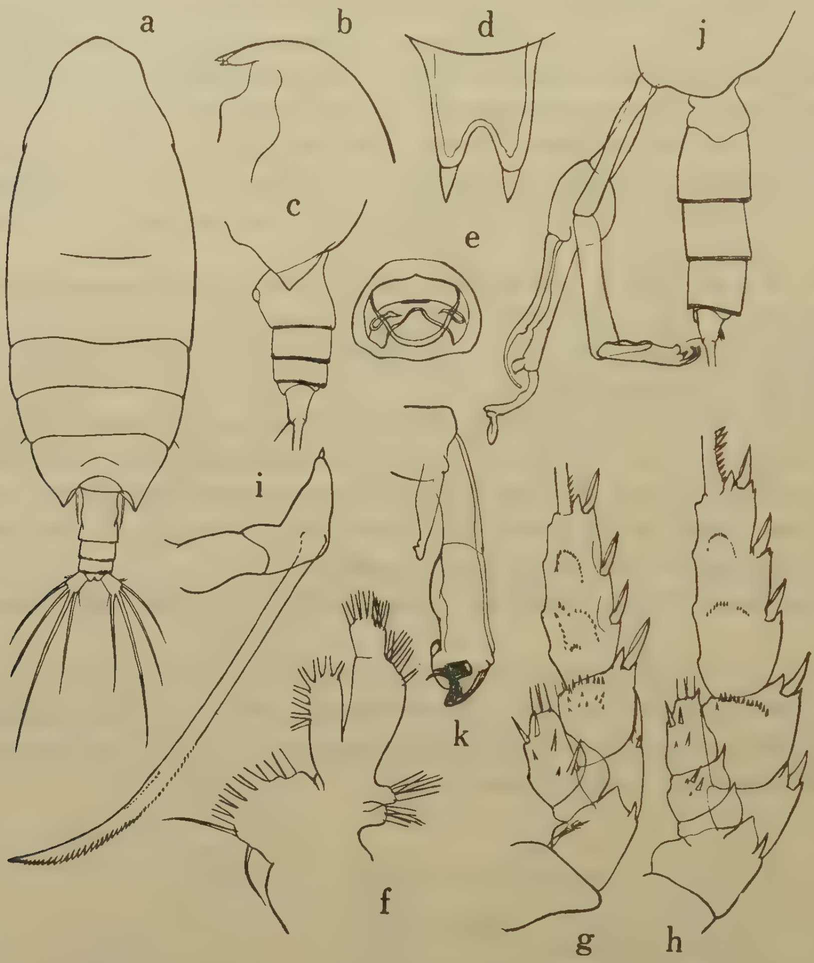

Fig. 109. *Scottcalanus rotundatus* sp. nov.
Female: a, dorsal aspect; b, head, lateral aspect; c, last thoracic segment and abdomen, lateral aspect; d, rostrum; e, genital opening; f, 1st maxilla; g, 2nd leg; h, 3rd leg; i, 5th leg. Male: j, last throacic segment and abdomen, lateral aspect; k, distal joints of left 5th leg.

segments are striated on the distal margin as are observed in other members of the genus.

The 1st antenna 23–jointed, extends to the end of the furca. The joints are in the following proportional lengths:

Joint	1	2	3	4	5	6	7	8–9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24–25
	39	45	22	22	27	29	47	27	27	31	38	52	52	52	52	52	54	54	52	52	49	54	61 =1000.

The 2nd antenna has the exopod 1.3 times as long as the endopod. The other mouth parts as those of *S. helenae* (Lubbock) (fig. f).

The 1st leg has 3-jointed exopod; the outer edge spine of the 2nd joint of the exopod is equal in length to the 3rd joint itself. The 2nd leg has 3–jointed exopod and 2-jointed endopod; the terminal spine of the exopod has 23 serrations the spinulation of the posterior surface of the exopod and endopod as shown in the figure (fig. g). The 3rd (fig. h) and 4th legs have each 3-jointed exopod and endopod. The 4th leg is devoid of spinules on the posterior surface of the exopod and endopod.

The 5th pair of legs 2-jointed. The distal joint bents inwardly at the proximal 1/3 of the joint. The subapical spine is about 4 times as long as the distal joint; the spine is coarsely serrated on the outer distal margin. The apical spine is very small (fig. i).

Male. Length, 4.8 mm : cephalothorax, 3.25; abdomen, 1.13 mm. The male has a general resemblance to the female. The lateral corner of the last thoracic segment narrowly rounded at the apical portion; the ventral margin of the segment much inflated.

The abdominal segments and furca are in the proportional lengths, 19:25:21:19:8:8=100. The 2nd to 4th segments are finely striated on the distal margin. The furcal rami about as long as wide.

The 1st antenna 20-jointed; the joints 8–13 are fused; the joints 24 and 25 are well separated. The joints are in the following proportional lengths:

Joint	1	2	3	4	5	6	7	8–9–10–11–12–13	14	15	16	17	18	19	20	21	22	23	24	25
	58	44	22	26	26	26	26	178	37	53	58	58	60	60	44	44	53	62	47	17=1000. (left side)

The joints 9 and 10, joints 12 and 13 are separated anteriorly. In the right antenna the joints 20 and 21 are fused.

The 2nd antenna has the exopod 1.5 times long as the endopod. The mandible has a robust 2nd basal joint and a narrow biting part. The maxillae and maxilliped as those of the female.

The 1st to 4th swimming legs as those of the female.

The 5th pair of legs resembles that of *S. helenae* (Lubbock). The endopod of the right leg is long, reaching the middle of the 2nd joint of the exopod of the same leg. The 1st joint of the exopod of the right leg has a small process on the distal inner margin. The distal joint of the exopod of the left leg has a pad of stiff hairs and two strong curved spines (fig. j, k).

Remarks. SEWELL has described a species of *Scottcalanus* which has no median crest under the name *S. investigatoris.* The present male specimen differs from *S. investigatoris* in its small size and in having a small process on the 1st joint of the right 5th leg. The female specimen devoid of median crest has never been described before.

Occurrence. 13 females accompanied with 6 males from the depth 1000–0 m. in the Izu region, December 1937.

Genus *Lophothrix* GIESBRECHT

Tow species, *Lophothrix frontalis* GIESBRECHT and *L. quadrispinosa* WOLFENDEN have been reported from the Malay Archipelago and Indian Seas. FARRAN recorded the occurrence of *L. latipes* (T. SCOTT) from the Great Barrier Reef region. SEWELL (1947) has recorded from the Arabian Sea *L. frontalis*, *L. humilifrons*, and *L. quadrispinosa.* From the Pacific WILSON has recorded *L. frontalis*, *L. humilifrons*, *L. latipes*, and *L. sarsi* WILSON. BRODSKY (1950) has recorded the occurrence of *L. frontalis* and *L. laticeps* from the Far-eastern and Polar Seas of the U.S.S.R. Up to the present time two species, *L. frontalis* and *L. humilifrons* have been recorded from the Izu region.

Lophothrix frontalis GIESBRECHT

(Fig. 110, a–j)

Lophothrix frontalis, GIESBRECHT, p. 1895, p. 254, pl. 2, figs. 1–5 and 9–12; A. SCOTT, 1909, p. 99, pl. 26, figs. 11–20, and pl. 29, figs. 1–10; WITH, 1915, p.211, figs. 66, 67 and pl. 7, fig. 7; SARS, 1925, p. 162, pl. 45, figs. 9–12, and pl. 46, figs. 1–7; SEWELL, 1929, p. 193, text-figs. 70–73; JESPERSEN, 1934, p. 87; SEWELL, 1947, p. 148, text-figs. 37, A–D, and 38, A–F; BRODSKY, 1950, p. 244, fig. 154; WILSON, 1950, p. 250.

Female. Length, 6.90 mm: cephalothorax, 5.56 mm; abdomen, 1.34 mm. The proportional lengths of the cephalothorax and abdomen are as 81 to 19. The head fused with the 1st thoracic segment, so are the 4th with the 5th. The head has a median crest (fig. a). The last thoracic segment narrowly rounded laterally (fig. b). The rostrum strongly bifurcate, with small point at the apex (fig. c).

The abdominal segments and furca are in the proportional lengths: 37:20:17:9:17=100. The genital segment about as long as wide, slightly contracts proximally. The lateral margin of the segment carries a small tuft of hairs on the either side near the base when viewed from the lateral (fig. b). The first to 3rd segments are fringed with fine teeth on the distal border. The furcal rami about as long as wide.

The 1st antenna extends to the end of the abdomen. The joints 24 and 25 are well separated; the joint 24 is 1.87 times as long as the 25th. The mouth parts and swimming legs as described and figured by the previous authors (fig. d). But the spinulation on the posterior surface of the 2nd and 3rd legs seems to be variable, and differs even in the right and left legs of the same individual.

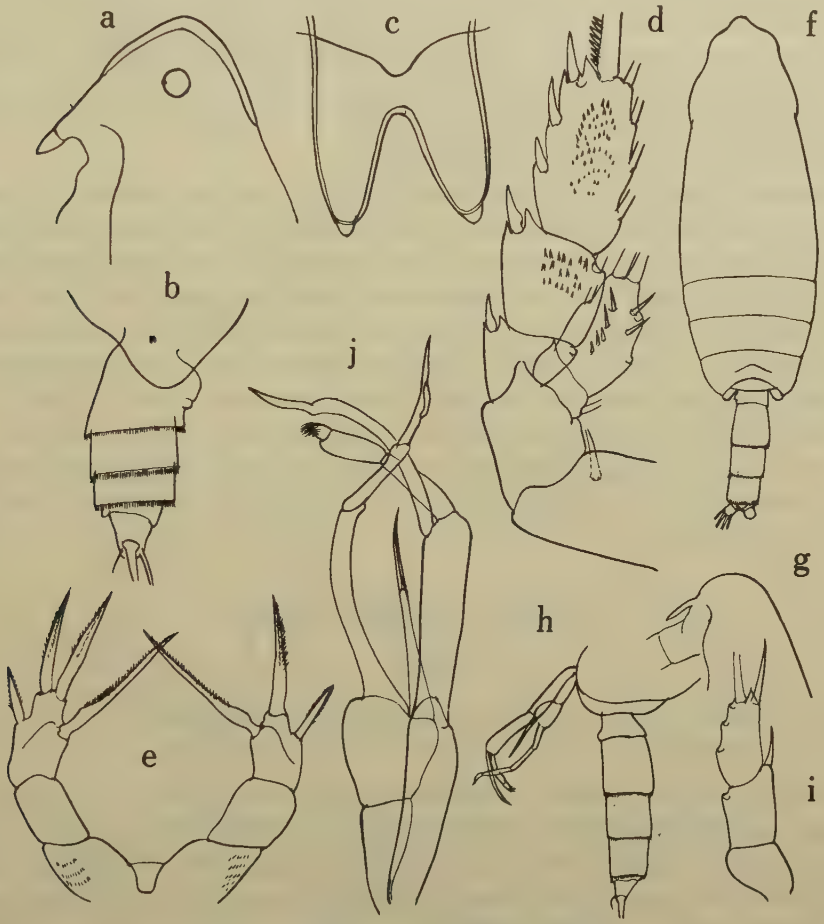

Fig. 110. *Lophothrix frontalis* GIESBRECHT.
Female: a, head, lateral aspect; b, last thoracic segment and abdomen, lateral aspect; c, rostrum; d, 2nd leg; e, 5th pair of legs. Male: f, dorsal aspect; g, head, lateral aspect: h, last thoracic segment and abdomen, lateral aspect; i, exopod of 1st leg; j, 5th pair of legs.

The 5th pair of legs 3-jointed, carries 3 spines on the distal joint. The 1st joint is furnished with rows of spinules on the posterior surface. An individual had and abnormal right 5th leg carrying 4 spines on the distal joint (fig. e).

Male. Length, 5.39 mm: cephalothorax, 3.95 mm; abdomen, 1.44 mm. The head has no median crest, but highly arched in front (fig. f, g). The rostrum consists of two fairly long spines. The abdominal segments and furca are in the proportional lengths: 13:30:22:22:4:9=100.

The 1st antenna extends to the end of the 2nd abdominal segment. The joints 8 to 12 are fused; the joints 12 and 13 fused posteriorly. The 2nd antenna has the exopod slightly shorter than the endopod (27:29) The mandible has a robust 2nd basal joint. In the 1st maxilla the outer lobe is large and carries 9 setae; the exopod has 9 setae. The 2nd maxilla somewhat reduced. The 1st leg as in the female (fig. i).

The left 5th leg has a fairly long endopod, reaching the distal end of the 2nd basal joint of the right leg (fig. h, j).

Remarks. SEWELL (1929) has called attention to the presence of two size groups in the female of this species. His specimens of the large form measured 6.250 and 6.718 mm. The small from 5.033–5.330 mm, and 4.750–5.633 mm. According to SEWELL (1947) the difference between these two forms, apart from size, the is the presence in forma *minor* of a row of spines on the ventro-posterior surface of the 1st joint of the 1st antenna near the distal margin. My specimens from the Izu region measured 5.80–6.90 mm. These specimens have no row of spines on the 1st joint of the 1st antenna, and belong to form a *major* SEWELL.

Occurrence. The species is fairly common in the deep waters of the Izu region.

Distribution. The specimes has a wide distribution in the Atlantic, Indian, and Pacific Oceans.

Lophothrix humilifrons SARS

(Fig. 111, a–f)

Lophothrix humilifrons, SARS, 1925, p.166, pl. 46, figs. 15–22; JESPERSEN, 1934, p. 87; SEWELL, 1947, p. 152, text-fig. 39, A; WILSON, 1950, p. 250, pl. 25, figs. 370–373.

Female. Length, 6.45 mm: cephalothorax, 5.20 mm; abdomen, 1.25 mm. The proportional lengths of the cephalothorax and abdomen are as 81 to 19. The cephalothorax elongate ovate. The head fused with the 1st thoracic segment, and the last two thoracic segments are fused (fig. a). The head has no median crest; the frontal margin obtusely rounded in lateral aspect (fig. b). The lateral distal corner of the last thoracic segment narrowly rounded (fig. c). The rostrum strong and bifurcate.

The abdomen 4-segmented; the segments and furca are in the proportional lengths, 39:18:14:18:11–100. The genital segment about as long as wide. The furcal rami longer than wide (20:18). The first 3 segments are fringed with fine teeth on the distal margin.

The 1st antenna 24-jointed, exceeds the distal end of the furca by terminal 1 joint; the joints are in the following proportional lengths:

Joint	1	2	3	4	5	6	7	8–9	10	11	12	13	14
	55	58	27	27	30	27	27	60	33	36	42	49	49
	15	16	17	18	19	20	21	22	23	24	25		
	49	49	52	52	52	44	42	38	36	44	22=1000.		

The 2nd antenna has the exopod about as long as the endopod; the distal joint of the exopod is short. The other mouth organs and the swimming leg as those of *L. frontalis* GIESBRECHT (fig. d, e).

The 5th pair of legs 3-jointed, resembles that of *L. frontalis.* The 1st and 2nd joints are furnished coarsely with small spines on the anterior surface (fig. f).

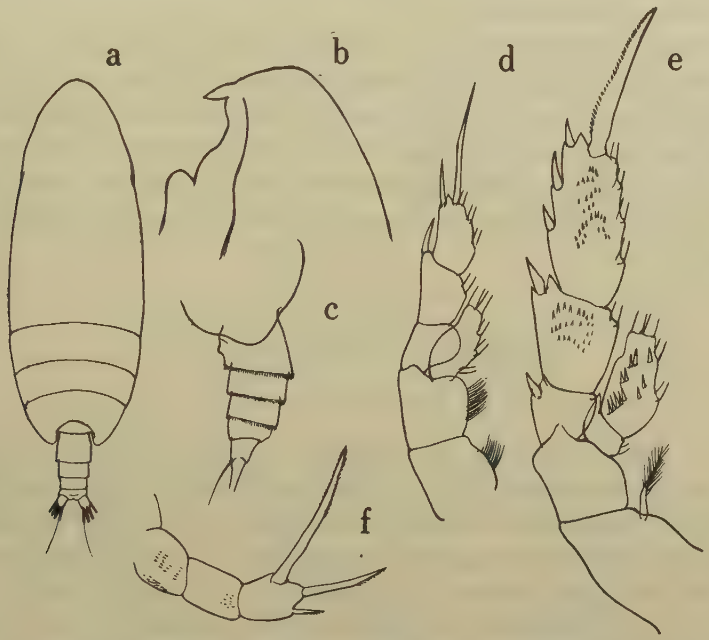

Fig. 111. *Lophothrix humilifrons* G. O. SARS.
Female: a, dorsal aspect; b, head, lateral aspect; c, last thoracic segment and abdomen, lateral aspect; d, 1st leg; e, 2nd leg; f, 5th leg.

Occurrence. One female from the depth 1800–1000 m in Suruga Bay, April 1940.

Distribution. The species has been recorded from the temperate Atlantic near Azores by SARS, west Greenland waters by JESPERSEN, Arabian Sea by SEWELL, and from the Pacific near Philippine Islands by WILSON.

Genus *Undinothrix* gen. nov.

Description. Female. Cephalothorax oblong ovate. Head fused with the 1st thoracic segment. 4th and 5th thoracic segment incompletely separate. Lateral corner of the last thoracic segment produced into a triangular expansion. Rostrum bifurcate, pointed at the apex, to which a filament-like spines are attached.

Abdomen 4–segmented. Furcal rami furnished with ordinary 4 setae and a short appendicular seta.

1st antenna 23–jointed; the joints 8–9, and 24–25 are fused. 2nd antenna with the exopod about as long as the endopod. Mandible has a slender endopod; biting part as usual. 1st maxilla has 5 setae on the exopod. 2nd maxilla as in *Lophothrix* GIESBRECHT, with sensory appendages on the distal lobes. In maxilliped the 1st basal joint has a slender bud-like sensory appendage about the middle of the anterior margin; the proximal outer margin of the 2nd basal joint is rather coarsely serrated; the distal 2 joints of the endopod have each a well developed outer marginal seta.

1st leg has 3–jointed exopod and unjoined endopod; the joint of the exopod has no outer edge spine. 2nd leg has 3–jointed exopod and 2–jointed endopod. 3rd and 4th legs have each 3–jointed exopod and endopod. Posterior surface of the exopod and endopod of the 2nd to 4th legs are furnished with spinules.

5th pair of legs symmetrical, composed of 3 joints; the terminal joint is furnished with 3 spines, of which the apical two are very strong and coarsely denticulated.

Male unknown.

Undinothrix spinosa sp. nov.

(Fig. 112, a–o)

Female. Length, 2.14 mm: cephalothorax, 1.16 mm; abdomen, 0.98 mm. The cephalothroax oblong ovate. The head fused with the 1st thoracic segment. The last two thoracic segments are incompletely separated (fig. a). The frontal margin of the head broadly rounded in lateral aspect (fig. b). The last thoracic segment asymmetrical; the distal margin of the segment is more produced on the left side (fig. d, e). The lateral distal margins of the segment are outwardly curved when viewed from the dorsal. The abdomen 4–segmented. The segments and furca are in the proportional lengths, 43 : 18 : 18 : 7 : 17 = 100. The genital segment swollen laterally about the middle. The ventral surface of the segment slightly concave at the genital area; the dorsal surface convex. The furcal rami longer than wide. The appendicular seta small.

The 1st antenna 23–jointed, extends to the distal end of the 2nd abdominal segment. The joints are broad in proportion to their lengths. The proportional lengths of the joints are as follows:

Joint	1	2	3	4	5	6	7	8–9	10	11	12	13	14
	51	51	22	23	28	28	31	60	32	32	37	41	42

	15	16	17	18	19	20	21	22	23	24–25	
	46	50	51	51	51	51	51	46	51	74	= 1000.

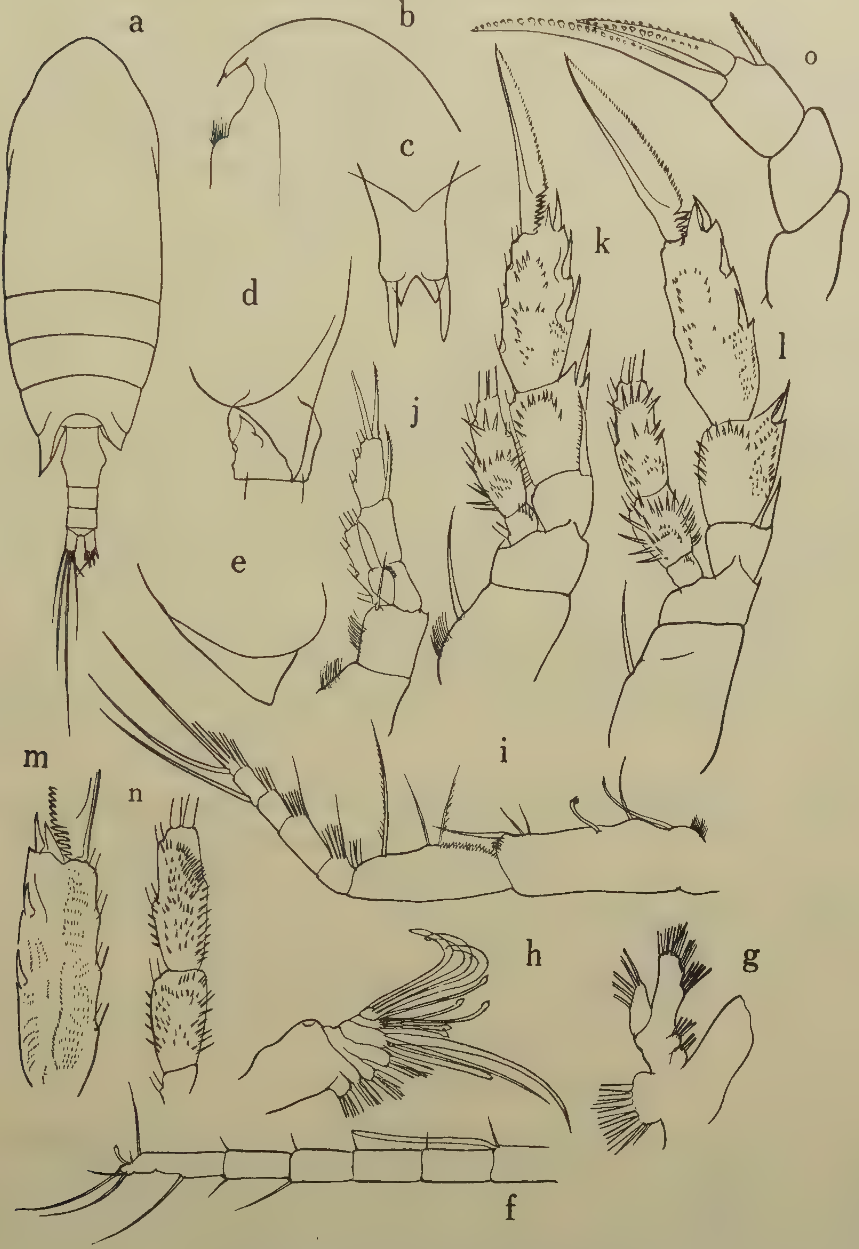

Fig. 112. *Undinothrix spinosa* sp. nov.

Female: a, dorsal aspect; b, head, lateral aspect; c, rostrum; d, last thoracic segment left sides, lateral aspect; e, last thoracic segment, right side, lateral aspect f, distal joints of 1st antenna; g, 1st maxilla; h, 2nd maxilla; i, maxilliped; j, 1st leg; k, 2nd leg; l, 3rd leg; m, 3rd joint of 4th leg; n, endopod of 4th leg; o, 5th leg.

The 2nd antenna has the exopod about as long as the endopod. The mandible has a slender endopod. The 1st maxilla has 9 setae on the outer lobe, 5 setae on the exopod, 9 setae on the endopod, 5 setae on the 2nd basal joint (fig. g). The 2nd maxilla has 3 worm-like, and 5 small bub-like sensory filaments on the endopod (fig. h). The maxilliped is characteristic; the 2nd basal joint is coarsely dentate on the proximal anterior margin; the outer marginal setae on the 4th and 5th joints of the endopod are well developed (fig. i).

The 1st leg has 3-jointed exopod and 1-jointed endopod. The 1st joint of the exopod has no outer marginal spine; the outer marginal spines on the 2nd and 3rd joints of the exopod are slender and long (fig. j). The 2nd leg has 3-jointed exopod and 2-jointed endopod. The outer edge spine of the 1st joint of the exopod is long, and is furnished with fine spinules on the inner margin. The 2nd and 3rd joints of the exopod and the 1st and 2nd joints of the endopod are furnished with rows of spinules on the posterior surface. The terminal spine of the exopod has a characteristic arrangement of teeth as shown in the figure (fig. k). The 3rd and 4th legs have each a 3-jointed exopod and endopod. The posterior surface of the exopod and endopod of the 4th leg is more finely furnished with spinules (fig. l).

The 5th pair of legs symmetrical, 3-jointed. The joints are of about equal length. The terminal joint has 3 spines, of which the apical two are very strong and are furnished with denticles on the outer distal margin; the outer marginal spine is short and is furnished with small denticles on either side of the spine (fig. o).

Remarks. The present specimen has a general resemblance to the members of the genus *Lophothrix* GIESBRECHT in the structure of the appendages but can be distingushed from them by the characteristic features of the rostrum, and by the strong terminal spines of the 5th pair of legs. It is also a character that the distal two joints of the 1st antenna are completely fused.

Occurrence. 7 females from the depth 1000–0 m in Sagami Bay, November 1937.

Genus *Scolecocalanus* FARRAN

The genus was created by FARRAN (1936) to accomodate the species closely allied to *Scottcalanus*. It is distinguished from the latter by the shape of the rostrum, the spinulation on the 2nd and 3rd joints of the exopod of the 4th leg, and the 1-jointed left 5th leg. FARRAN indicates that the genus has some affinities to the genus *Macandrewella* A. SCOTT in having a lenticular thickening at the base of the rostrum. FARRAN has described two species, *Scolecocalanus galeatus* and *S. lobatus* from the Great Barrier Reef Sea. Up to the present time I have failed to detect any of the species in my collection.

Genus *Macandrewella* A. Scott

A. Scott created the genus *Macandrewella* in 1909 and included *M. jonae* and *M. chelipes* (Giesbrecht) obtained from the Malay Archipelago. Sewell has described *M. chelipes* and *M. scotti* Sewell from the Indian Seas. Farran added three more species of the genus, *M. asymmetrica*, *M. sewelli*, and *M. mera* taken from the Great Barrier Reef Sea. Wilson has (1950) recorded *M. agassizi* Wilson, *M. chelipes*, and *M. sewelli* Farran from the Pacific Ocean. I have been unable to find any of the species from the Izu region.

Genus *Scaphocalanus* Sars

A. Scott has recorded the occurrence of *Scaphocalanus magnus* (T. Scott), *S. major* (T. Scott) and *S. elongatus* A. Scott from the Malay Archipelago. From the Indian Seas Sewell (1929) has detected four species *S. affinis* Sars, *S. elongatus*, *S. magnus*, and *S. medius* Sars, of which he referred the last one to *S. major* (T. Scott). Farran has recorded *S. echinatus* Farran from the Great Barrier Reef, and Sewell (1947) recorded *S. magnus* (T. Scott) from the Arabian Sea. From the Far-eastern and Polar Seas of the U.S.S.R. Brodsky has recorded *S. magnus*, *S. affinis*, *S. medius*, *S. polaris* Brodsky, *S. brevicornis*, Sars, *S. subbrevicornis* Wolfenden, *S. insignis* Brodsky, *S. subelongatus* Brodsky, *S. minutus* Tanaka, *S. gracilicaudatus* Tanaka, *S. obscurus* (Esterly), and *S. similis* ?(T. Scott). Wilson (1950) has recorded the occurrence of *S. affinis*, *S. angulifrons* Sars, *S. brevicornis*, *S. echinatus*, *S. insolitus* Wilson, *S. magnus*, *S. medius*, *S. robustus* (T. Scott), *S. subbrevicornis* from the Pacific Ocean.

Up to the present time I have found the following 12 species: *S. magnus*, *S. affinis*, *S. elongatus*, *S. major*, *S. impar* (Wolfenden), *S. brevicornis*, *S. longifurca* (Giesbrecht), *S. subbrevicornis*, *S. echinatus*, *S. curtus* Farran, *S. minutus* Tanaka, and *S. gracilicaudatus* Tanaka. Among these *S. minutus* appears to be the male of *S. brevicornis* Sars, and *S. gracililicaudatus* to be the male of *S. subbrevicornis* Wolfenden. *S. impar* Wolfenden has been recorded only from the Antarctic, now it extended the geagraphical distribution to the North Pacific.

The species of the genus *Scaphocalanus* resemble each other so closely in general appearance and in the structure of the 5th pair of legs that it is very difficult to discriminate them. Moreover, the 5th legs of the female exhibit a considerable degree of variability in the porportional lengths and the number of spines on the distal joint. The 5th pair of legs is often furnished with abnormal endopod as illustrated by Vervoort (1957) in *S. brevicornis* Sars. I have detected the similar examples in my specimen of *S. affinis* Sars and *S. echinatus* Farran.

Scaphocalanus magnus (T. SCOTT)

(Fig. 113, a–i)

Amallophora magna, T. SCOTT, 1894, p. 55, pl. 4, figs. 5–9; *Scaphocalanus magnus,* A. SCOTT, 1909, p. 97; WITH, 1915, p. 189, pl. 7, figs. 8, a–d, pl. 8, figs. 6, a–g, text-fig. 58, a–k; FARRAN, 1926, p. 257; SEWELL, 1929, p. 207; JESPERSEN, 1934, p. 87; SEWELL, 1947, p. 144, text-fig. 35, a–i; WILSON, 1950, p. 328; BRODSKY, 1950, p. 247, fig. 156; VERVOORT, 1957, p. 111.

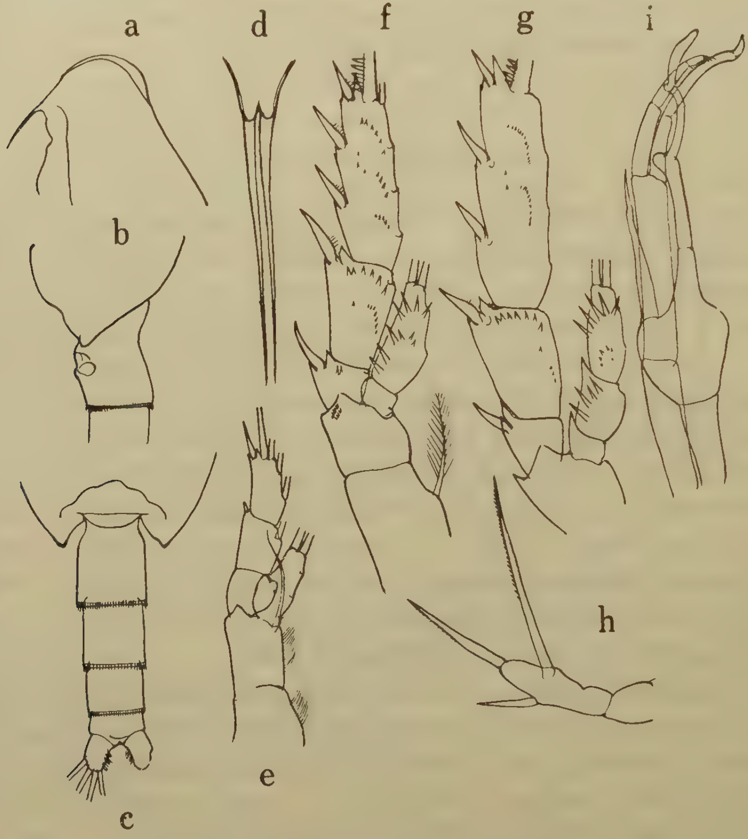

Fig. 113. *Scaphocalanus magnus* (T. SCOTT).
Female: a, head, lateral aspect; b, last thoracic segment, lateral aspect; c, last thoracic segment and abdomen, dorsal aspect; d, rostrum; e, 1st leg; f, 2nd leg; g, 3rd leg; h, 5th leg. Male: i, 5th pair of legs.

Female. Length, 4.39–4.85 mm. The anterior and posterior regions of the body have the proportional lengths as 77 to 23. The head has a median crest and is produced anteriorly, but not so highly arched (fig. a). The last thoracic segment produced triangularly and narrowly rounded at the apex (fig. b) According to WITH the lateral distal corner of the last thoracic segment are variable in shape. The rostral filaments long and slender (fig. d).

The abdomen 4-segmented. The segments and furca are in the following proportional lengths: 36 : 24 : 20 : 6 : 15 = 100. The genital segments not produced below on the ventral surface. The 1st to 3rd segments are fringed with fine teeth on the distal margin. The furcal rami 1.7 times as long as wide.

The 1st antenna extends to the distal margin of the genital segment; the 1st joint has a row of short hairs on the posterior distal margin as illustrated by SEWELL. The 2nd antenna has the endopod about 1.4 times as long as the exopod (72 : 53). The 2nd maxilla has 8 filaments on the diatal joints of which three are long and worm-like, and the remainings are bud-like.

The swimming legs are in the main feature as those figured by previous authors (fig. e). The 2nd leg has the outer edge spine on the 1st joint of the exopod, which extends to the middle of the outer margin of the 2nd joint of the exopod (fig. f); the posterior surface of the joints of the exopod and endopod are furnished with groups of spinules. The anterior surface of the joints of the exopod and endopod of the 2nd to 4th legs are furnished with patches of minute spinules.

In the 5th pair of legs the outer marginl spine reaches the distal margin of the joint. The terminal spine is about as long the 2nd joint. The inner marginal spine 2.5 times as long as the 2nd joint; the spine is furnished with fine spinules on the distal 2/3 of the spine (fig. h).

Male. Length, 4.65 mm : cephalothorax, 3.13 mm ; abdomen, 1.52 mm. The anterior and posterior regions of the body have the proportional lengths as 67 to 33. The frontal margin of the head obtusely rounded, and has no median crest. The lateral distal corner of the last thoracic segment rounded.

The abdomen 5-segmented. The segments and furcal rami are in the proportional lengths:

Segment	Abd. 1	2	3	4	5	Furca
	13	33	21	24	2	7 =100.

The furcal rami about as long as wide.

The 1st antenna extends to the distal end of the last thoracic segment. The joints 8 to 12 and joints 24 and 25 are fused; the joints 20 and 21 are fused on the right side. The joints are in the following proportional lengths:

Joint	1	2	3	4	5	6	7	8-9-10-11-12	13	14
	72	90	43	29	32	29	29	150	26	26

	15	16	17	18	19	20	21	22	22	34-25
	32	43	43	43	43	38	40	58	67	67 =1000.

The 1st joint of the 1st antenna has a row of fine spinules on the posterior distal margin.

The 2nd antenna has the exopod about as long as the endopod. The mandible palp is conspicuous; the exopod 2 times as long as the endopod. The 1st mixilla has 7+2 setae on the outer lobe, 7 setae on the exopod. The 2nd maxilla feeble.

The 1st to 4th swimming legs as in the female.

The 5th pair of legs reaches back to the distal margin of the 2nd abdominal segment. The endopod of the right leg extends a little beyond the distal margin of the 2nd basal joint of the left leg. The exopod of the left leg is about 4/5 the length of the endopod of the same leg. The endopod of the left leg 2-jointed, but there is a notch on the proximal 1/3 of the inner margin of the endopod (fig. i).

Remarks. Sizes hitherto been reported are as follows: GIESBRECHT, 4.50 mm; SARS, 5.0 mm; A. SCOTT, 4.5 mm; WOLFENDEN, 3.70–4.25 mm; WITH, 5.23 mm; SEWELL, 4.90 mm; VERVOORT, 3.90–4.75 mm. According to WOLFENDEN the specimens from the South Atlantic are smaller than those from the North Atlantic. SEWELL (1947) has called attention to the presence of two forms in the female specimens of *S. magnus* taken from the Arabian Sea. The large form measured 4.967 mm, and the small measured 3.550 mm. These forms differ in the proportions of the body segments and also in the proportional lengths of the segments of the 1st antenna. The present specimens, though much larger than SEWELL's specimen of forma *minor*, agree with forma *minor* in the proportional lengths of the abdominal segments and the 1st antenna. A specimen measuring 4.45 mm had the 1st antenna with the segments in the following proportional lengths:

Segment	1	2	3	4	5	6	7	8–9–10	11	12	13	14
	80	80	212	21	27	24	26	70	14	27	37	43
	15	16	17	18	19	20	21	22	23	24–25		
	43	50	51	53	50	48	54	54	59	54	=1000.	

These figures agree with those of forma *minor* given by SEWELL. His measurements of the proportional lengths of the segments of the abdominal segments and furca are 33:24:20:8:15=100 in the forma *minor*, and 31:28:20:7:14=100 in the forma *major*. The present specimen comes near to forma *minor* in the proportional lengths of the abdominal segments and the 1st antenna. But the 2nd to 4th swimming legs have patches of very small spinules on the anterior surface of the 2nd basal segment. These patches of fine spinules are present also on the anterior surface of the 1st basal segment, although those of the 2nd leg are extraordinary fine. In the 5th pair of legs the specimen has a moderately long spine on the outer lateral margin of the terminal segment.

Distribution. The species has a wide distribution in the deep waters of the Atlantic, Indian and Pacific Oceans. The species has been recorded from the Malay Archipelago, Arabian Sea and Far-eastern and Polar Seas of the U.S.S.R. VERVOORT has recorded the species from 45°S.

Occurrence. Eight females and one male from Suruga Bay, and one male from Sagami Bay in the hauls from deep waters, July, 1937.

Scaphocalanus affinis (G. O. SARS)

(Fig. 114, a–j)

Amallophora affinis, SARS, 1905, p. 21; *Amallophora gracilis*, WOLFENDEN, 1911, p. 265, fig. 39, a–c; *Scaphocalanus affinis*, SARS, 1925, p. 171, pl. 48, figs. 15–23; FARRAN, 1929, p. 248; SEWELL, 1929, p. 205; JESPERSEN, 1934, p. 89, 131; WILSON, 1950, p. 324, pl. 17, figs. 220, 221, pl. 33, fig. 503; BRODSKY, 1950, p. 249; VERVOORT, 1957, p. 113, figs. 96, 100, 101.

Female. Length, 5.40 mm: cephalothorax, 4.08 mm; abdomen, 1.32 mm. The proportional lengths of the cephalothorax and abdomen are as 75 to 25. The forehead has a median crest. The frontal margin of the head broadly rounded in lateral aspect (fig. a, b). The last thoracic segment produced into triangular expansion which is bluntly pointed at the apex (fig. c). The shape of the apex of the last thoracic segment is variable as in *S. magnus*.

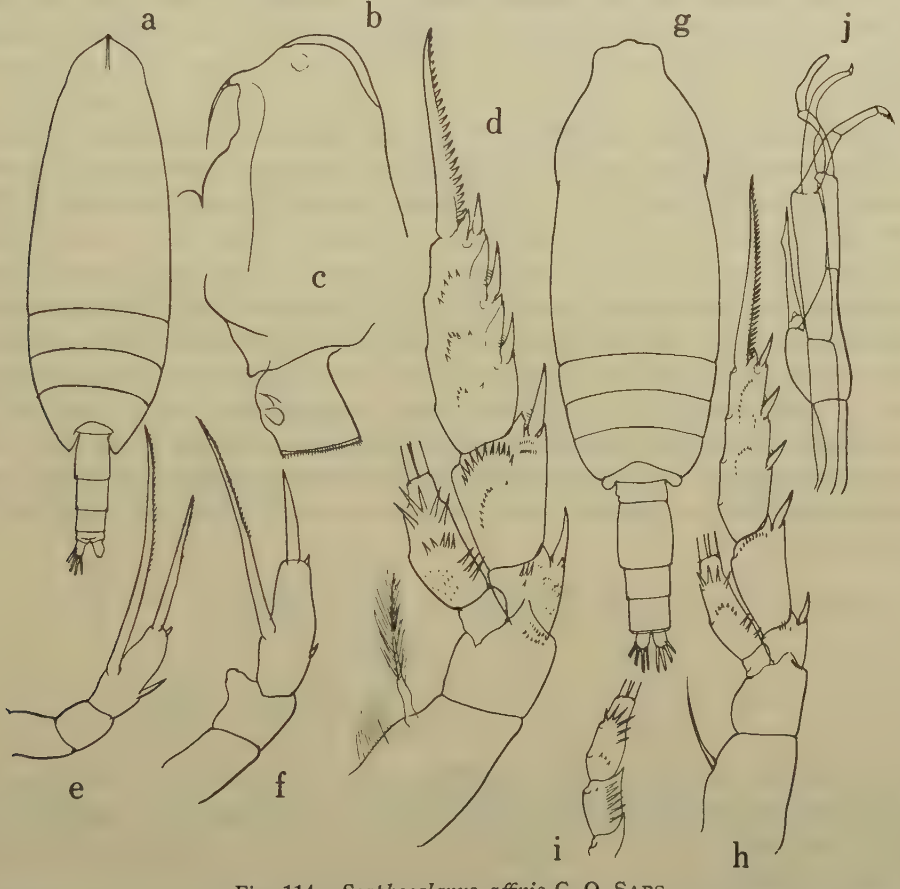

Fig. 114. *Scaphocalanus affinis* G. O. SARS.
Female: a, dorsal aspect; b, head, lateral aspect; c, last thoracic segment, lateral aspect; d, 2nd leg; e, 5th leg; f, 5th leg, other specimen. Male: g, dorsal aspect; h, 2nd leg; i, endopod of 3rd leg; j, 5th pair of legs.

The abdomen 4-segmented. The proportional lengths of the segments and furca are as 34 : 24 : 21 : 6 : 15 = 100. The furcal rami 1.8 times as long as broad.

The 1st antenna broken off in the distal segments. The segments 1 to 16 are in the following proportional lengths:

Segment	1	2	3	4	5	6	7	8-9-10	11	12	13	14	15	16
	43	47	13	13	14	13	13	32	10	11	17	17	19	21.

The 2nd antenna has the endopod about 1.4 times as long as the exopod. The other mouth parts as in *S. magnus*.

The 2nd leg has an outer edge spine not reaching the middle of the outer margin of the 2nd segment of the exopod (fig. d). The patches of fine spinules are observed on the anterior surface of the 2nd basal joint of the 2nd to 4th legs.

The 5th pair of legs 3-jointed. The distal segment has four spines, of which two outer marginal ones are short. The inner marginal spine is about 2 times as long as the 3rd joint itself. The terminal spine is longer than the 3rd joint itself (fig. e).

A specimen measuring 5.30 mm had the 5th pair of legs whith a rudimentary endopod on the inner distal corner of the 2nd segment. Its apical spine was much shorter than the distal segment (fig. f). Another specimen measuring 4.81 mm had the 5th pair of legs which have a rudimentary endopod furnished with an apical spine. The specimen had the cephalothorax and abdomen in the proportional lengths as 77 to 23. The abdominal segments and furca are in the proportional lengths, 38 : 23 : 18 : 5 : 15 = 100. The 1st antenna extends to the distal margin of the last thoracic segment. The segments are in the following proportional lengths:

Segment	1	2	3	4	5	6	7	8-9-10	11	12	13	14
	87	80	25	25	27	25	25	70	22	27	37	40
	15	16	17	18	19	20	21	22	23	24-25		
	42	49	47	49	47	47	47	52	65	65	=1000.	

The 1st segment has a row fine spinules on the posterior distal margin. The mouth parts and swimming legs as in *S. affinis*. The specimen, though smaller in size than the specimen above described, is an example of *S. affinis* with abnormal 5th pair of legs.

Male. Length, 4.50 mm : cephalothorax, abdomen, 1.25 mm. The cephalothorax elongate ovate. The head contracts much in front (fig. g). The last thoracic segment broadly rounded in lateral aspect. The rostrum has two slender filaments.

The abbomen is contained 2.6 times in the length of the cephalothorax. The 2nd segment robust, 2 times as long as the 3rd.

The 1st antenna extends a little beyond the distal margin of the 3rd thoracic segment. The right antenna is 19-jointed; the segment 8 to 12 are completely fused; the segments 12 and 13 are partially fused; the segments 20 and 21 are fused.

The mouth parts well developed except the 2nd maxilla which is soft-skined and bears only long filaments on the distal segment.

The 2nd leg had 36 teeth on the terminal spine of the exopod (fig. h).

The 5th pair of legs has a general resemblance to those of the other members of the genus. It extends to fhe distal margin of the 3rd abdominal segment. The endopod of the right leg is long, reaching the distal margin of the 2nd basal segment of the left leg; there is a small process on the proximal part of the endopod. In the left leg the endopod 2-jointed, and slightly longer than the exopod (fig. j).

Remarks. The present species closely resembles S. *magnus* (T. SCOTT) but can be distinguished from it by the following characters: the head is broadly rounded; the 5th leg 3-jointed; the distal segment has two small outer marginal spines, an apical, and an inner marginal spines. The present specimen is much larger in size than that reported by SARS which measured only 3.6 mm in the female. FARRAN's specimens from the Antarctic measured 5.05–5.10mm. VERVOORT's specimens from the Antarctic are 4.82–5.36 mm in the female and 4.73 mm in the male. S. *gracilis* WOLFENDEN is probably, as has been stated by SARS or FARRAN, identical with S. *affinis* (SARS). It differs from the latter only in the length of the terminal spine on the distal segment of the 5th leg in the female.

Occurrence. Four females and two males from the depth 1000 m to the surface.

Distribution. The species has a wide distribution in the deep waters of the Atlantic, Incian and Pacific Oceans. It has been recorded also from the Antarctic.

Scaphocalanus elongatus A. SCOTT

(Fig. 115, a–h)

Scaphocalanus elongatus, A. SCOTT, 1909, p. 98, pl. xxxii, figs. 10–16; SEWELL, 1929, p. 205, fig. 77, a–k; *Scaphlcalanus brevicornis,* BRODSKY, 1950, p. 252, fig. 160, ♂H5 (male).

Female. Length, 2.56–3.14 mm. The proportional lengths of the cephalothorax and abdomen are as 76 to 24. The frontal margin of the head evenly rounded. No median crest wast observed on the forehead (Fig. a) The last thoracic segment produced triangularly with a slight projection at the apex, which directs some what ventrally (fig. c).

The abdomen 4-jointed. The segments and furca are in the proportional lengths:

Segment	Abd. 1–2	3	4	5	Furca	
	31	21	20	8	20	=100.

The genital segment about as long as wide, not produced below, but concave at the genital area. There is a patch of fine hairs on the posterior periphery of the genital opening. The distal border of the segment is finely striated with teeth. The 2nd and 3rd segments are also striated on the distal border. The furcal rami 2.5 times as long as wide.

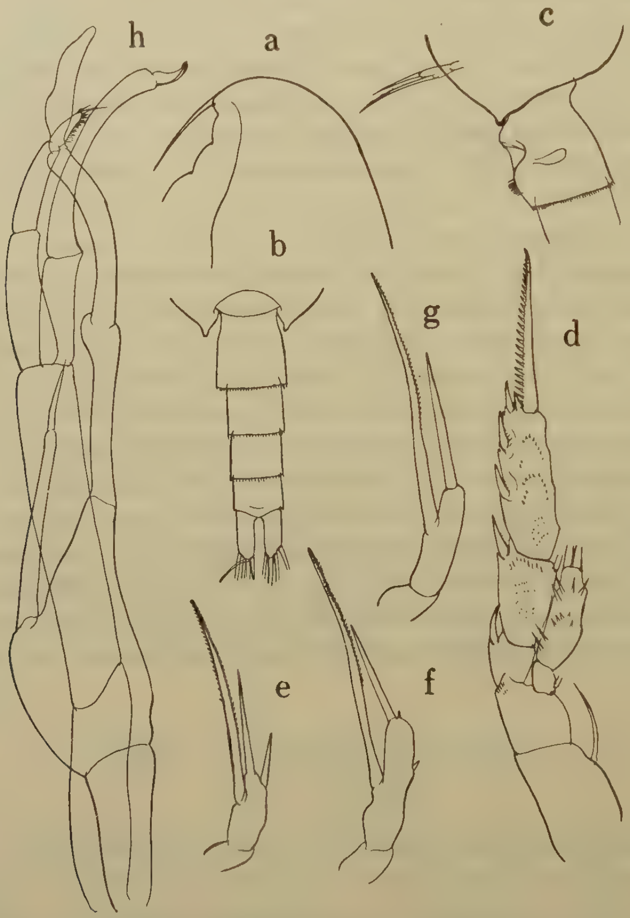

Fig. 115. *Scaphocalanus elongatus* A. SCOTT.
Female: a, head, lateral aspect; b, last thoracic segment and abdomen, dorsal aspect; c, last thoracic segment, lateral aspect; d, 2nd leg; e, 5th leg; f, 5th leg, other specimen; g, 5th leg, another specimen. Male: h, 5th pair of legs.

The 1st antenna broken off in the distal segments. The 1st segment has a row of fine spinules on the posterior distal border.

The 2nd antenna has the endopod 1.3 times as long as the exopod. The other mouth organs are as those of the foregoing species.

In the 2nd leg the terminal spine of the exopod had 21 teeth (fig. d). The

2nd basal segment of the 2nd to 4th legs is furnished with patches of fine spinules as in *S. magnus* and *S. affinis.*

The 5th pair of legs 2–jointed. The terminal segment bears 3 spines, one on each margin and one on the apex (fig. e). In some specimen the segment has only 2 spines, one on the inner margin and one on the apex (fig. g). The another speciemen hnd 4 spines of which two on the outer margin are very small (fig. f).

Male. Length, 2.55–2.86 mm. The cephalothorax and abdomen are in the proportional lengths as 63 to 37, or 64 to 36. The frontal margin of the head truncate in dorsal view. It is obtusely rounded in lateral view. The postero-lateral margin of the last thoracic segment rounded.

The abdomen is composed of 5 segments, has the following proportional lengths: 6 : 36 : 22 : 26 : 2 : 8 = 100. The 4th segments 2 times as long as it is wide at the proximal (28 : 14), and is slightly inflated towards the distal margin. The anal segment very short, concealed benath the foregoing when viewed from the dorsal. The furcal rami divergent, 1.5 times as long as wide.

The 1st antenna extends at least to the end of the 3rd thoracic segment. The left antenna 19–segmented. The segments 8 to 12, 13 and 14 are fused. The distal segments are missing in the specimen dissected. The segments have the following proportional lengths in 0.01 m.:

Joint	1	2	3	4	5	6	7	8–9–10–11–12	13–14
	18	19	10	5	5	5	5	20	11
	15	16	17	18	19	20	21	22	23
	5	8	9	8	8	6	7	9	10 = 1.000.

The 1st segment has a row of spinules near the posterior distal margin.

In the 2nd leg the outer marginal spine of the 1st segment of the exopod is short and curved inwardly. The spine does not reach the middle of the outer margin of the next segment. The terminal spine of the exopod has about 50 serrations.

The 5th pair of legs reaches back to the distal margin of the 2nd abdominal segment. The endopod of the left leg 3–segmented. The inner margin of the endopod produced at the proximal 1/3 of the endopod where the 1st segment connects with the 2nd. The endopod of the right leg is slender and long, extending about to the distal end of the 2nd basal segment of the left leg (fig. h).

Remarks. It has been generally accepted that *S. elongatus* A. SCOTT, has a close resemblance to *S. affinis* SARS. SARS (1925) regarded *S. elongatus* as identical with his *affinis* which has a distinct median crest. SEWELL (1929) in his description of *S. elongatus* remarks that the forhead bears a linear crest. In A. SCOTT's original description of the species he states that the forehead appears narrowly rounded, and it is faintly thickened in the middle line, which may indicate a very weak crest, but the material was too limited to make certain. He shows no crest in his figure of the species. In the present specimens the foreheand has neither linear crest nor thickened part on the middle line. SEWELL has described and figured an example of an abnormal 5th pair of legs which has two spines on the terminal segment and a process on the inner margin of the segment. BRODSKY's male specimen of *S. brevicornis* has the endopod composed of three joints on the left leg, which agrees well with that found in the present male specimen. *S. brevicornis* has according to VERVOORT's figure 2-jointed endopod on the male left 5th leg (fig. 99, c).

Occurrence. 7 females and 2 males from deep water of Sagami Bay.

Distribution. The species has been recorded from the Malay Archipelago and Indian Seas.

Scaphocalanus major (T. SCOTT)

(Fig. 116, a–i)

Scolecithrix major, T. SCOTT, 1894, p. 52, pl. 3, 5; *Amallophora media*, SARS, 1907, p. 16; *Scaphocalanus major*, A. SCOTT, 1909, p. 97; *Scolecithrix gracilipes*, FARRAN, 1909, p. 52, pl. vi, figs. 1–4; *Scaphocalanus medius*, SARS, 1925, p. 173, pl. xlix, figs. 1–8; SEWELL, 1929, p. 208; BRODSKY, 1950, p. 250, fig. 158; WILSON, 1950, p. 328, figs. 515–517; *Scaphocalanus major*, VERVOORT, 1957, p. 110.

Female. Length, 2.66 mm. The proportional lengths of the cephalothorax and abomen are as 76 to 24. The cephalothorax elongate ovate, about 2.6 times as long as it is widest at the 1st thoracic segment. The frontal margin of the head narrowly rounded in dorsal view, and obtusely rounded when viewed from the lateral. The last thoracic segment obtusely triangular on the posterior distal corner, but not pointed at the apex (fig. a).

The abdomen is composed of 4 segments. The segments and furcal rami are in the following proportional lengths:

Segment	Abd. 1–2	3	4	5	Furca	
	42	25	23	9	21	=100.

The genital segment slightly produced below. The ventral margin distal to the genital opening is furnished with hairs. The genital, 2nd, and 3rd segments are fringed with fine teeth on the distal margin. The furcal rami about 2 times as long as wide.

The 1st antenna broken off in the distal segments. The 1st segment is furnished with a row of spinules on the posterior distal margin.

The 2nd antenna has the endopod about 1.2 time as long as the exopod. The other mouth parts as those of the foregoing species.

In the 2nd leg (figs. b, b′) the outer marginal spine of the 1st segment of the exopod is slightly shorter than half the length of the 2nd segment of the exopod, and curved inwardly. The terminal spine of the exopod has about 30 serrations. The 1st basal segment of the 2nd leg has a small patch of minute spinules on the posterior surface near the proximal inner margin. The anterior surface of the segment has also several patches of spinules. The 2nd basal segment is furnished with spinules both on the posterior and anterior surfaces. These patches of minute spinules on the basal segments are remarkable in the 3rd and 4th legs. The exopod and endopod of the 2nd to 4th legs are furnished with groups of spinules on the posterior surface, and with patches of minute spinules on the anterior surface. The 3rd leg has about 26 serrations on the terminal spine of the exopod (fig. c).

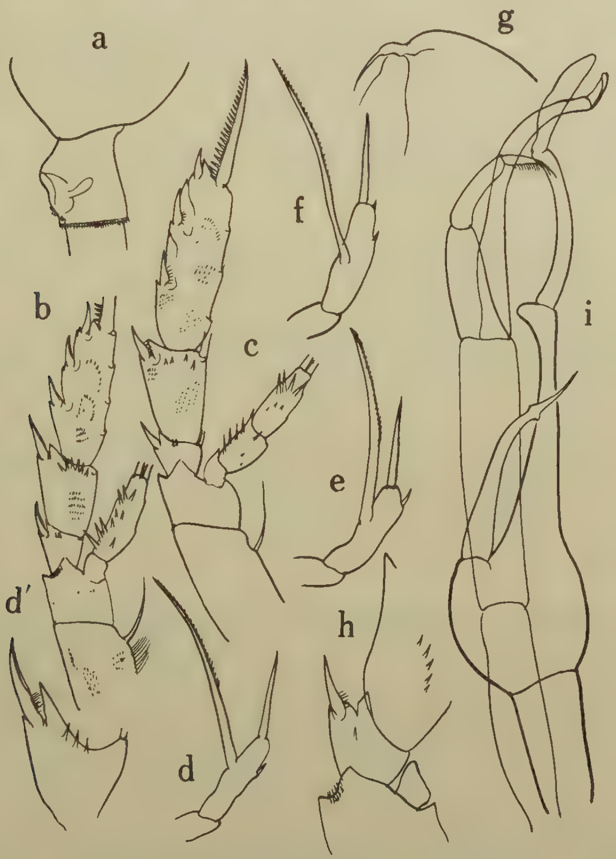

Fig. 116. *Scaphocalanus major* (T. Scott).
Famale: a, last thoracic segment, lateral aspect; b, 2nd leg; b′, 1st segment of exopod of 2nd leg (enlarged); c, 3rd leg; d, 5th leg; e, 5th leg, other specimen; f, 5th leg; another specimen. Male: g, head, lateral aspect; h, exopod of 2nd leg; i, 5th pair of legs.

The 5th pair of legs 2-jointed. The distal segment has 3 spines. The inner marginal spine is about 2 times as long as the terminal one, and is rather finely serrated on the outer border. The outer marginal spine is short, about 1/4 the length of the terminal spine, and arises distal to the line of origin of the inner marginal spine (fig. d, e, f).

Male. Length, 2.55–2.76 mm. The cephalothorax and abdomen are in the proportional length as 65 to 35. The lateral margins of the head constricted much in front. The frontal margin of the head obliquely rounded when viewed from the lateral (fig. g). The 5th thoracic segment separates from the 4th; this is clearly seen from the side.

The abdomen 5-segmented. The segments and furca are in the proportional lengths:

Segment	Abd. 1	2	3	4	5	Furca	
	9	35	23	23	1	9	=100.

The furcal rami about 1.4 times as long as wide (15:11).

The 1st antenna 19-segmented; the segments are in the following proportional lengths:

Segment	1	2	3	4	5	6	7	8–9–10–11–12	13–14
	91	103	40	30	27	24	27	121	45

	15	16	17	18	19	20–21	22	23	24–25	
	30	48	45	51	51	76	42	73	76	=1.000.

In the 2nd leg the outer marginal spine on the 1st segment of the exopod is short, not reaching the middle of the outer margin of the following segment (fig. h). The 1st basal segment constricted laterally near the distal end. The outer margin is furnished with poor short hairs about the middle of the segment. The posterior surface of the exopod is furnished with groups of spinules, but they are poorer than those found in the female. The patches of minute spinules found in the anterior surface of the exopod and endopod of the female of the 2nd leg were not detected in the male. The terminal spine of the exopod has about 40 serrations.

The 5th pair of legs reaches back about to the distal end of the 2nd abdominal segment. The endopod of the left leg 2-jointed, and slightly inflated proximally (fig. i). In other respects the 5th pair of legs resemble those of the foregoing species.

Remarks. A. SCOTT in his description of *S. major* (T. SCOTT) states that the last thoracic segment, when viewed from the side, appears very narrowly rounded, but there is no indication of a point as in *S. magnus* (T. SCOTT) or *S. elongatus* A. SCOTT. In the original description of *S. major*, though T. SCOTT gives no account on the shape of the last thoracic segment, his figure shows (pl. fig. 44) that the lateral corner of the last thoracic segment is obtusely rounded. In *S. medius* Sars the postero-lateral corner of the last thoracic segment is also obtusely rounded.

In the female 5th pair of legs of both *S. major* and *S. medius* the distal segment has 3 spines, of which the one on the outer margin is short, and arises near the face of the terminal spine. This outer marginal spine divides the outer margin of the segment in the proportions as 4 to 1 in Sars' *medius*. In an example measuring 2.67 mm has the 5th legs in which the outer marginal spine divides the outer margin of the segment in the same proportions as found in the Sars' *medius*. The 5th pair of legs of *S. major* has, as shown in T. Scott's figure (pl. 3, fig. 26), the outer marginal spine which is placed very near to the base of the terminal spine.

Sewell (1929, 1947) has laid stress upon the presence of patches of minute spinules on the anterior surface of the 2nd basal segment of the 2nd to 4th legs. This feature is a common character found in the species belonging to the genus *Scaphocalanus*. The present specimen is identical with *S. medius* described by Sewell. There is no essential differendes between *S. medins* and *S. major* in the structure of the swimming legs. *S. gracillipes* (Farran) appears to be identical with *S. major* (T. Scott). But Farran (1926) agreed with With (1915) in regarding *S. gracilipes* to be a synonym of *S. brevicornis* Sars, after he had found a specimen which had the 5th legs similar to the type figured by Sars.

Occurrence. 30 females and 10 males in the hauls from the depth 1000 m to the surface.

Distribution. The species is widely distributed in the deep waters of the Atlantic, Indian, and Pacific Oceans.

Scaphocalanus brevicornis Sars

(Fig. 117, a–h)

Scaphocalanus brevicornis, With, 1915, p. 192, pl. 8, fig. 7, text-fig. 59; Farran, 1926, p. 258; 1929, p. 248, fig. 15; *Scaphocalanus minuta*, Tanaka, 1937, p. 262, pl. xviii, figs. 1–11 (male); *Scaphocalanus brevicornis*, Wilson, 1950, p. 326, pl. 33, figs. 507–509; Brodsky, 1950, p. 252, fig. 160; Vervoort, 1951, p. 113, figs. 60, 61; 1957, p. 107, figs. 97–99; Tanaka, 1960, p. 42, pl. 18, figs. 1–6.

Female. Length, 2.44–2.66 mm. The cephalothorax and abdomen are in the proportional lengths as 76 to 24. The head fused with the 1st thoracic segment, and so are the 4th with the 5th. The cephalothorax elongate ovate (fig. a). The frontal margin of the head rather narrowly rounded in lateral view (fig. b). The lateral corner of the last thoracic segment obtusely rounded when viewed from the side (fig. c). The rostrum has an inflated base to which fairly long filaments are attached.

The abdomen 4-segmented. The segments and furca are in the following proportional lengths measured from the dorsal:

Segment	Abd. 1–2	3	5	5	Furca	
	34	21	19	10	16	=100.

The genital segment slightly produced below. The furcal rami 2 times as long as broad. The first 3 segments are fringed with fine teeth on the distal margin.

The 1st antenna 22-jointed, extends to the posterior margin of the last thoracic segment. The segments are in the following proportional lengths:

Segment	1	2	3	4	5	6	7	8–9–10	11	12	13	14	15	16	17	18	19	20	21	22	23	24–25	
	71	100	33	29	29	25	29	67	21	21	33	37	42	50	50	50	46	42	46	46	58	18	=1.000.

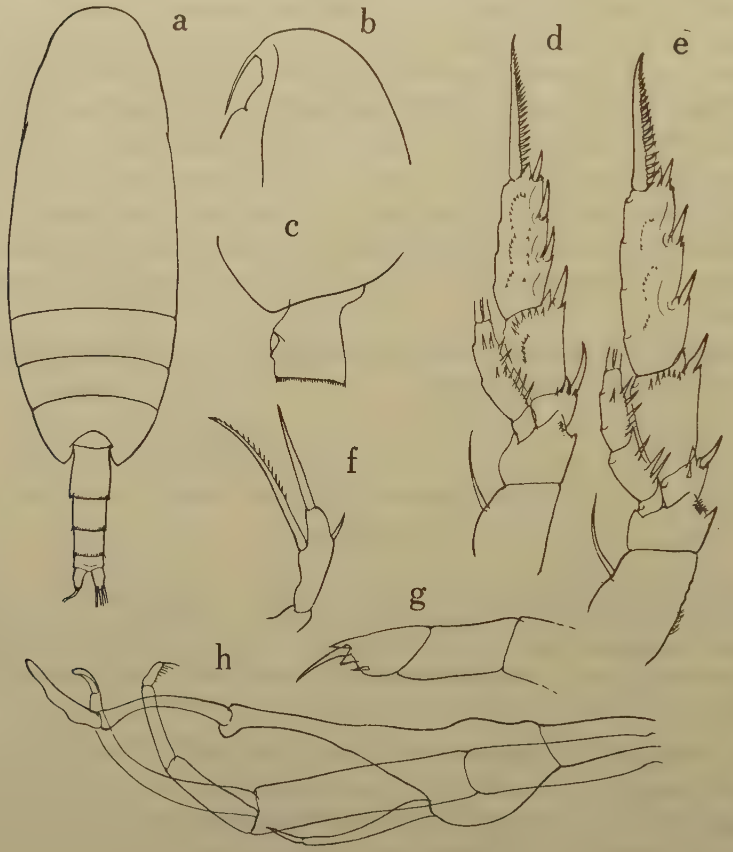

Fig. 117. *Scaphocalanus brevicornis* G. O. SARS.
Female: a, dorsal aspect; b, head, lateral aspect; c, last thoracic segment, lateral aspect; d, 2nd leg; e, 3rd leg; f, 5th leg. Male: g, 1st segment of exopod of 2nd leg; h, 5th pair of legs.

The 1st segment is furnished with a row of minute spine on the posterior distal margin. The segments 8, 12, 14, and 18 have each 2 setae; the segment 10 has a distal seta.

The 2nd antenna has the endopod 1.3 times as long as the exopod. The terminal segment of the 2nd maxilla have 3 long vermiform and 5 amalliform sensory filaments, of which 2 are larger; the setae on the 5th lobe are slender. The maxilliped has a row of fine spinules on the anterior proximal margin.

In the 2nd leg the outer marginal spine on the 1st segment of the exopod is long and curved, exceeding beyond the middle of the outer margin of the 2nd segment. The spinules of the posterior surface of the exopod and endopod as shown in the figure (fig. d). The terminal spine has 23–27 teeth. The 3rd leg has a group of spinules on the outer margin of the 1st basal segment (fig. e). The terminal spine of the exopod of the 3rd leg has 18–21 teeth. In the 4th leg the terminal spine of the exopod has 33 teeth.

The 5th pair of legs 2–jointed. The distal segment has 3 spines. The inner marginal spine is about 1.5 times as long as the apical spine, and is rather coarsely denticulated on the distal outer margin; the number of teeth is about 17. The terminal spine is about as long as the segment itself. The outer marginal spine arises opposite to the inner marginal spine, and divides the outer margin of the segment in the proportions 3:1 (fig. f).

Male. Length, 2.15–2.99 mm. The cephalothorax and abdomen are in the proportional lengths as 64 to 36. The abdomen 5–segmented. The segments and furca are in the proportional lengths:

Segment	Abd. 1	2	3	4	5	Furca	
	6	37	20	24	5	8	=100.

The 1st antenna 20–jointed, extends to the end of the 3rd thoracic segment. The segments 20 and 21 are fused on the right side.

The 2nd leg has a fairly long outer marginal spine on the 1st segment of the exopod. The spine is slightly curved inwards (fig. g.).

The 5th pair of legs reaches the distal end of the 2nd abdominal segment. The left leg has 3–jointed exopod and 2–jointed endopod. The distal segment of the endopod is small and turned at the apical portion. The endopod of the right leg styletform, reaches about the distal end of the 2nd basal segment of the left leg (fig. h).

Remarks. The species resembles closely *S. major* (Scott), differing from it in having a long outer edge spine on the 1st segment of the exopod of the 2nd leg. Vervoort (1957) illustrated an abnormal 5th pair of legs of the female which had a rudimentary endopod. The male specimen described and figured by me under the name *S. minuta* is, as pointed out by Vervoort, is the male of *S. brevicornis* Sars.

Occurrence. 8 females and 4 males from the deep water of the Izu region.

Distribution. The species has been recorded from the deep waters of the North Atlantic, Bay of Biscay, Antarctic, Far-eastern and Polar Seas of the U.S.S.R, and the Northwestern Pacific.

Scaphocalanus impar (WOLFENDEN)

(Fig. 118, a–d)

Amallophora impar, WOLFENDEN, 1911, p. 263, fig. 38.

Female. Length, 2.45 mm. The cephalothorax and abdomen are in the proportional lengths as 77 to 23. General appearance as in *S. brevicornis* SARS. The cephalothorax elongate ovate (fig. a). The last thoracic segment obtusely rounded in lateral aspect (fig. b).

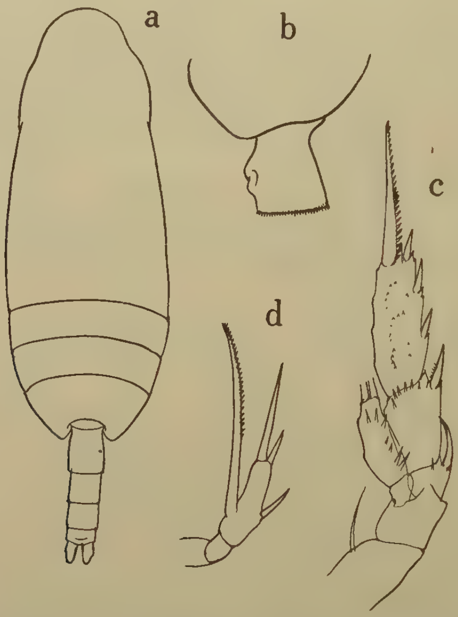

Fig. 118. *Scaphocalanus impar* (WOLFENDEN). Female: a, dorsal aspect; b, last thoracic segment, lateral aspect; c, 2nd leg; d, 5th leg.

The abdominal segments and furca are in the proportional lengths:

Segment	Abd. 1–2	3	4	5	Furca	
	35	21	18	15	12	=100.

The genital segment swollen slightly below. The furcal rami longer than wide (4:3).

In the 2nd leg the outer edge spine of the 1st segment of the exopod long and curved, reaching the middle of the outer margin of the 2nd segment; the terminal spine of the exopod has 23 teeth (fig. c)

The 5th pair of legs 3-jointed. The distal segment has 4 spines; the outer marginal spine arises opposite to the inner marginal spine, and is about 1/3 the length of the inner distal spine; the outer distal spine is about as long as the outer marginal spine; the inner marginal spine is about 2 times as long as the distal segment, and is rather coarsely serrated on the outer margin (fig. d).

Remarks. The species is closely allied to *S. brevicornis* Sars, but can be distinguished from the former by the armature on the 5th pair of legs. The present specimen has the 5th legs quite similar in structure to those figured by Wolfenden.

Occurrence. 2 females from deep water of Sagami Bay.

Distribution. The species has been recorded from the Antarctic.

Scaphocalanus subbrevicornis (Wolfenden)

(Fig. 119, a–k; fig. 120, a–f)

Amallophora subbrevicornis, Wolfenden, 1911, p. 262, fig. 37; *Scolecithrix glacialis*, Wolfenden, 1911, p. 251, fig. 30, (male); *Scaphocalanus subbrevicornis*, Farran, 1929, p. 249, fig. 16; *Scaphocalanus gracilicauda*, Tanaka, 1937, p. 262, figs. 12, a–f (male); ? *Scaphocalanus subbrevicornis*, Wilson, 1950, p. 331, pl. 34, fig. 518; *Scaphocalanus subbrevicornis*, Vervoort, 1951, p. 116, figs. 62–64; Brodsky, 1950, p. 253, fig. 161; Tanaka, 1953, p. 132; *Scaphocalanus macropes*, Tanaka, 1953, p. 132; *Scaphocalanus subbrevicornis*, Vervoort, 1957, p. 110; Tanaka, 1960, p. 331, pl. 34, p. 43, pl. xix, figs. 1–8.

Female. Length, 1.95 2.03 mm. The cephalothorax and abdomen have the proportional lengths as 76 to 24. The cephalothorax elongate ovate (fig. a). The postero-lateral corner of the last thoracic segment obtusely triangular (fig. b). The rostal filament long and slender.

The abdominal segments and furca are in the following proportional length;

Segment	Abd. 1–2	3	4	5	Furca	
	31	22	20	9	18	=100.

The genital segment about as long as wide, slightly swollen below. The furcal rami 2.5 times as long as wide.

The 1st antenna broken off in the distal segments. The 2nd antenna has the endopod about as long as the exopod (50:47). The other mouth parts as in *S. major* T. Scott.

In the 2nd leg the outer edge spine on the 1st segment of the exopod is short, about 1/3 the length of the outer margin of the 2nd segment of the exopod, and slightly curved inwards (fig. d, d′). The terminal spine of the exopod has about 24 teeth. No small triangular spines was observed on the posterior surface of the basal segments, but there are scattered small spines on the anterior surface of these segments.

The 5th pair of legs 2-jointed. The distal segment is slender. The terminal spine is longer than the segment itself. The inner marginal spine is about 1.8 times as long as the segment, and rather finely toothed on the outher margin (fig. f). The number of teeth about 32. The other specimen had the 5th pair of legs furnished with two small spines on the outer margin, one at the base of the terminal spine, and the other on the distal 1/4 of the outer margin (fig. g).

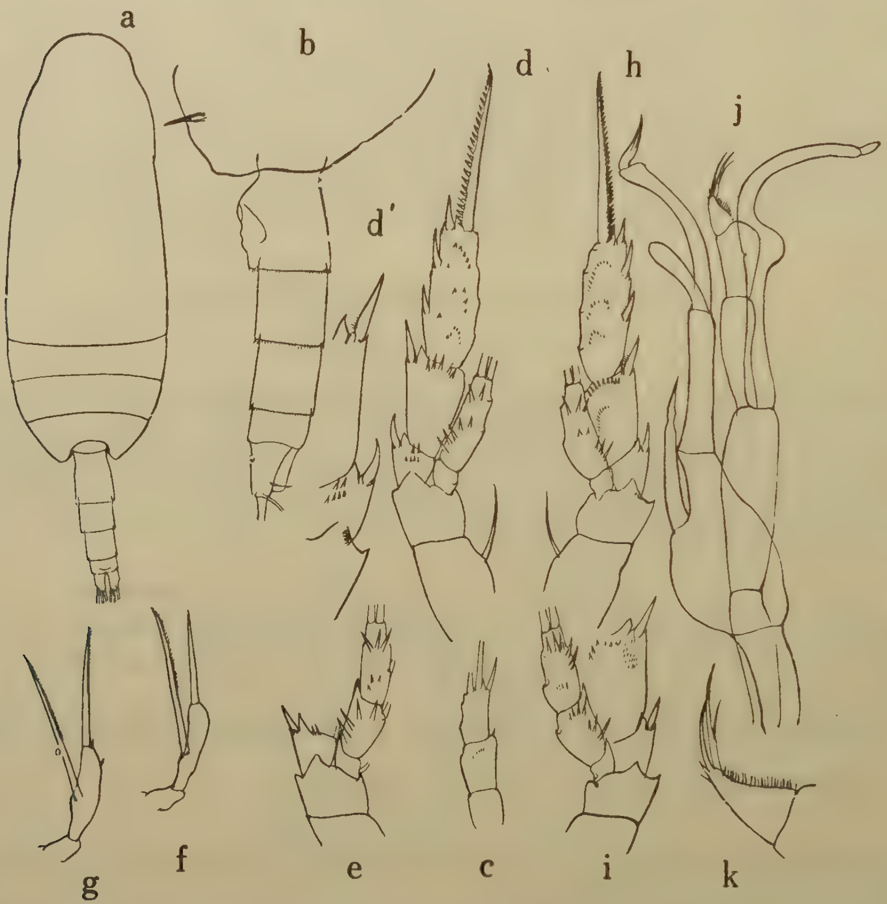

Fig. 119 *Scaphocalanus subbrevicornis* WOLFENDEN.
Female: a, dorsal aspect; b, last thoracic segment and abdomen, lateral aspect; c, exopod of 1st leg; *d*, 2nd leg; d′, 1st and 2nd segments of exopod of 2nd leg (enlarged); e, 3rd leg; f, 5th leg; g, 5th leg, other specimen. Male: h, 2nd leg; i, 3rd leg; j, 5th pair of legs; k, distal segment of left 5th leg.

Male. Length, 1.65–1.80 mm. The cephalothorax and abdomen are in the proportional lengths as 68 to 32. The cephalothorax elongate ovate. The head fused with the 1st thoracic segment. The 4th and 5th thoracic segments are incompletely separated. The lateral distal corner of the last thoracic segment rounded. The rostral filament attenuates gradually into a fine point.

The abdomen 5-segmented. The segments and furca are in the proportional lengths:

Segment	Abd. 1	2	3	4	5	Furca	
	10	29	25	23	2	11	=100.

The 3rd abdominal segment is usually longer than the 4th.

The 1st antenna 20-jointed on the left side, 19-jointed on the right side, extends to the end of the 3rd abdominal segment. The segments are in the following proportional lengths:

Segment	1	2	3	4	5	6	7	8–9–10	11–12–13	14	
	57	67	32	29	32	29	32	77	90	29	
	15	16	17	18	19	20	21	22	23	24–25	
	42	45	57	57	61	57	38	38	57	74	=1.000.

The 1st antenna measured 1.56 mm in total length.

The 2nd antenna has the exopod about as long as the endopod. The mandible has the exopod as long as the endopod. The 1st maxilla has 5 setae on the exopod, 7 long and 2 short setae on the outer lobe; the endopod and inner lobes are reduced. The 2nd maxilla reduced, has soft-skined filaments on the distal segments. The maxillipede as those of those of the other member of the genus.

In the 2nd leg the outer edge spine on the 1st segment of the exopod is short and straight (fig. h). The terminal spine of the exopod has 34 teeth.

The 5th pair of legs extends to the distal margin of the 3rd abdominal segment. The right leg has a short endopod which extends slightly beyond the distal margin of the 2nd basal segment of the left leg. The 1st segment of the exopod has a fairly long process on the distal margin of the segment. The endopod of the left leg 1-jointed, but there is a slight notch on the middle of the outer margin where the segment swollen outwardly (fig. j). The distal segment of the exopod of the left leg as figured (fig. k).

Remarks. There has been a considerable confusion on the identification between two species, *S. subbrevicornis* Wolfenden and *S. longifurca* Giesbrecht. These species resemble each other in general appearance and in the structure of the 5th pair of legs. According to Wolfenden (1911) the female 5th pair of legs are incompletely 3-jointed. The 3rd segment is 2 times as long as the 2nd. The terminal spine of the 3rd segment is about half as long as the inner marginal spine. In *S. longifurca* the inner marginal spine is according to Giesbrecht's figure of the female 5th leg (pl. 37, fig. 16). 2.5 times as long as the terminal one. My specimen has the slender 5th leg which comes nearest to those illustrated by Vervoort (1951). The specimen taken by the Japanese Antarctic

Research Expedition has the 5th leg quite similar in structure given by VERVOORT.

WOLFENDEN has not given any account on the 2nd leg of *S. subbrevicornis.* FARRAN (1929) states that the outer edge spine on the 1st segment of the exopod of the 2nd leg is shorter than that on the 2nd segment in both species. In *longifurca* it is described as "hakig" but it is straight or nearly so in *subbrevicornis.* FARRAN is of opinion that *subbrevicornis* and *longifurca* are identical. On comparing the description and figures of these two species given by WOLFENDEN and GIESBRECHT they differ so little from each other that it seems very likely to regard the both species as different. But there remains, as have been pointed out by FARRAN or VERVOORT, some differences between them in the structure of the 2nd antenna and 2nd leg. It seems better, at present, to keep the both species as distinct. WILSON (1950) has recorded the occurrence of *S. subbrevicornis* from the Hawaiian and Philippine Islands. VERVOORT believes that WILLSON's specimen is an example of *S. longifurca.* But WILSON's figure of the 5th pair of legs comes

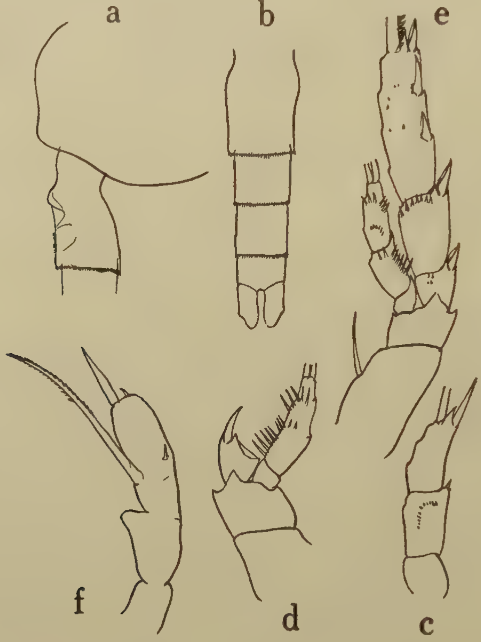

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Fig. 120. ? *Scaphocalanus subbrevicornis* WOLFENDEN. Female: a, last thoracic segment, lateral aspect; b, abdomen, dorsal aspect; c, exopod of 1st leg; d, 2nd leg; e, 3rd leg; f, 5th leg.

near to those given by FARRAN (1929, fig. 16, b) except that inner marginal spine is shorter and the 2nd segment is furnished with a rudimentary endopod in WILSON's specimen. WILSON gives no account on the other characters in his description of the species. I have listed in 1953 a species under the name *Scaphocalanus macropes*. The specimen measured 1.92 and 2.30 mm respectively. These specimens have the 5th pair of legs similar in structure to those of *subbrevicornis* figured by FARRAN (1929), only differing from it in having a rudimentary endopod (Fig. 120, f). But there are some differences between them in the 2nd leg: the outer edge spine on the 1st segment of the exopod is short and slightly curved, but the small spines on the 2nd segment of the endopod are more in numbr in the present specimen (Fig. 120, d).

The male of *subbrevicornis* has been described and figured by VERVOORT (1951). *Scolecithrix glacialis* WOLFENDEN is, as suggested by VERVOORT, the male of *subbrevicornis*. I have in 1937 described a male of *Scaphocalanus* under the name *gracilicauda*. The specimen measured 1.75 mm in total length, and has the 5th pair of legs quite similar to that of *subbrevicornis* figured by VERVOORT.

Occurrence. 5 females and 4 males from the deep water of the Izu region.

Distribution. The species has been recorded from the Antarctic by WOLFENDEN, FARRAN, and VERVOORT. The species appears to have a fairly wide distribution also in the deep waters of the Pacific.

Scaphocalanus longifurca (GIESBRECHT)

(Fig. 121, a–g; fig. 122, a–e)

Scolecithrix longifurca, GIESBRECHT, 1892, p. 266, pl. 13, fig. 19, pl. 37, fig. 16; ? *Scaphocalanus insignis*, BRODSKY, 1950, p. 254, fig. 162; *Scaphocalanus tempolaris*, TANAKA, 1953, p. 132 (male); *Scaphocalanus glacialis*, TANAKA, 1953, p. 132 (male).

Female. Length, 1.48–1.67 mm. The cephalothorax and abdomen are in the proportional lengths as 78 to 22. General appearance as in *S. subbrevicornis* (WOLFENDEN). The lateral distal corner of the last thoracic segment triangularly produced, but narrowly rounded at the apex (fig. a).

The abdominal segment and furca are in the proportional lengths:

Segment	Abd. 1–2	3	4	5	Furca	
	37	20	17	9	18	=100.

The genital segment produced below. The furcal rami 2 times as long as wide.

The 1st antenna broken off in the distal segments in the specimen dissected.

The 2nd natenna has the endopod 1.25 times as long as the exopod. The other mouth appendages as those of the other members of the genus.

In the 2nd leg the outer edge spine of the 1st segment of the exopod is about half the length of the outer margin of the following segment, and curved (fig. b).

The terminal spine of the exopod has 24 teeth. The 3rd leg has the basal joints coarsely covered with small triangular spines one the anterior surface.

The 5th pair of legs 2-jointed. The distal segment delated at the distal part. The terminal spine is rather short, about half the length of the distal segment. The inner marginal spine is about 3 times as long as the terminal one, and finely serrated one each side of the spine (fig. c).

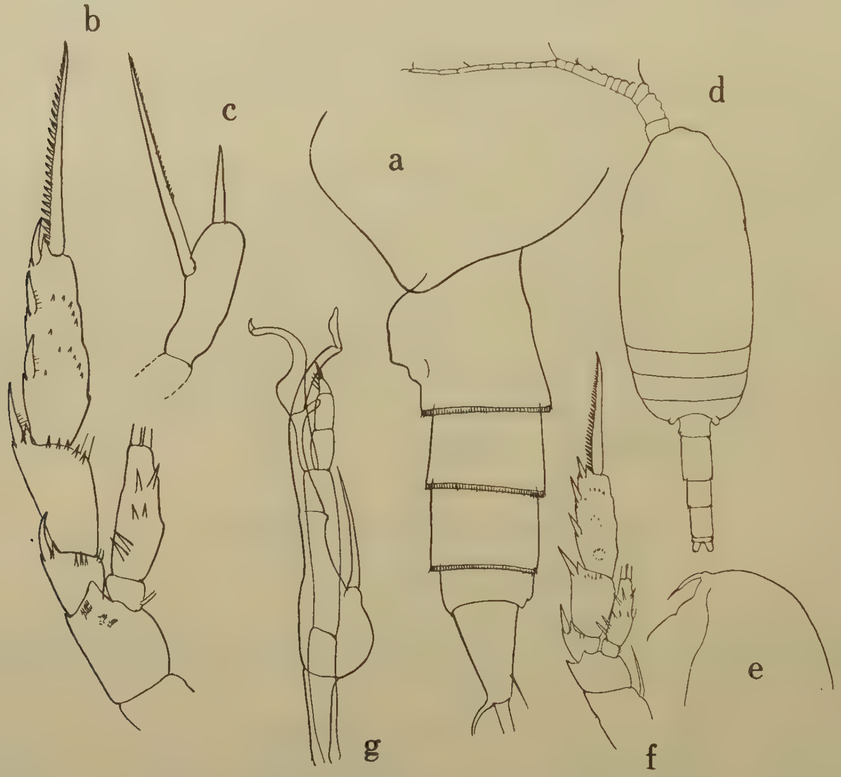

Fig. 121. *Scaphcocalanus longifurca* (GIESBRECHT).
Famale: a, last tharacic segment and abdomen, lateral aspect: b, 2nd leg: c, 5th leg. Male: d, dorsal aspect; f, e, head, lateral aspect; f, 2nd leg; g, 5th pair of legs.

Male. Length, 1.30–1.35 mm. The cephalothorax and abdomen are in the proportional lengths as 69 to 31. The head slightly produced anteriorly in dorsal aspcect (fig. d), and obtusely rounded in lateral aspect. The lateral distal corner of the last thoracic segment rounded. The rostrum strong, gradually attenuates to a fine point (fig. e).

The abdominal segments and furca are in the following proportional lengths:

Segment	Abd. 1	2	3	4	5	Furca
	13	28	23	23	2	12 =100.

The furcal rami slightly divergent.

The 1st antenna 19 jointed on the left side, 18–jointed on the right side, they extend to the posterior margin of the 3rd thoracic segment. The segments are in the following proportional lengths (right side):

Segment	1	2	3	4	5	6	7	8–9–10–11–12–13	14
	65	98	47	33	33	22	33	142	38

15	16	17	18	19	20–21	22	23	24–25	
33	49	49	49	49	65	33	77	83	=1.000.

The 2nd antenna has the exopod slightly longer than the endopod (22:19).

The 1st leg has no outer edge spine on the 1st segment of the exopod. The 2nd segment has a small outer edge spine. The posterior surface of the segment has a transverse row of minute spines. In the 2nd leg the outer edge spine on the 1st segment of the exopod is short and straight (fig. f). The terminal spine of the exopod has about 30 teeth.

The 5th pair of legs extends to the distal margin of the 3rd abdominal segment. The endopod of the left leg is swollen at the middle section. The exopod 3–jointed, and short. The endopod of the right leg is long, reaches the distal margin of the 1st segment of the exopod of the left leg (fig. g).

Remarks. Scaphocalanus longifurca has, according to Giesbrecht, the 2nd antenna which has the exopod longer than the endopod, and the 2nd leg has a curved outer edge spine on the 1st segment of the exopod. The present female specimen has a slightly curved outer edge spine on the 1st segment of the exopod of the 2nd leg. But in the 2nd antenna the exopod is shorter than the endopod. The 5th pair of legs agrees fairly well with the description and figure of the 5th leg given by Giesbrecht with the exception that the small spine on the outer margin of the distal segment is absent in the present specimen. A specimen measuring 1.57 mm. had the 5th pair of legs furnished with a small outer marginal spine near the baseof the terminal spine (Fig. 122, e). The specimen has a straight outer edge spine on the 1st segment of the exopod of the 2nd leg, and the terminal spine of the exopod is more finely serrated on the outer margin (Fig. 122, c).

The present male resembles also closely *S. subbrevicornis* except the following characters: the 1st antenna is short, only reaching the distal margin of the thoracic segment, and the segments have the proportional lengths which differ from those found in *S. subbrevicornis*; the distal segment of the exopod of the left 5th leg is furnished with only 3 stiff hairs on the inner margin, whereas, it is furnished in *subbrevicornis* with, beside 2 strong spines, fine hairs on the inner margin. The present male has been listed under the name *S. glacialis* by me in 1953. I have in the same year listed the another male specimen under the name *S. tempolaris*. The specimen measured 1.76 mm in total length, and has a general resemblance to the male specimen above described. But the specimen differs from the foregoing in having a longer abdomen and in having the segments of the 1st antenna which differ from those of the foregoing. The specimen had the cephalothorax and abdomen with the proportional lengths as 95 to 41. The abdominal segments and furca are in the proportional lengths:

Segment	Abd. 1	2	3	4	5	Furca
	7	38	23	23	2	7 =100.

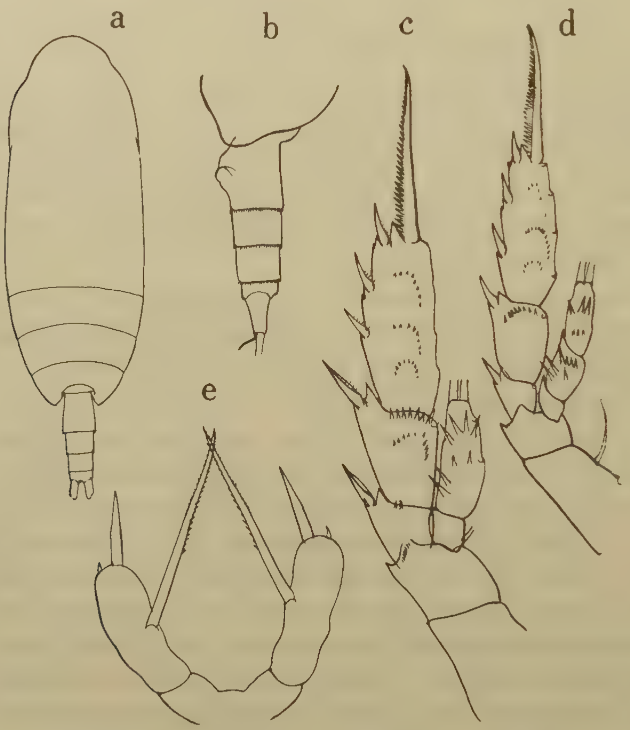

Fig. 122. ? *Scaphcocalanus longifurca* (GIESBRECHT).
Female: a, dorsal aspect; b, last thoracic segment and abdomen, lateral aspect; c, 2nd leg; d, 2rd leg; e, 5th pair of legs.

The 1st antenn 19-jointed on the left, 18-jointed on the right side, extend to the end of the 3rd thoracic segment. The segments are in the following proportional lengths:

Segment	1	2	3	4	5	6	7	8-9-10-11-12-13	14
	79	107	51	28	32	23	28	144	37
	15	16	17	18	19	20	21	22	23	24-25
	28	46	42	46	46	28	41	42	69	83 =1.00.

The specimen, though slightly larger in size, and differs in some details from the male above described under the name *longifurca* may perhaps be identical with it in having the 5th pair of legs quite similar in structure to that of *S. longifurca*. *Scaphocalanus insignis* Brodsky appears to be identical with the present species.

Occurrence. 5 females and 4 males from the deep water of the Izu region.

Distribution. The species has been recorded by Giesbrecht from the North Pacific between 11°N and 14°N. The species appears to be widely distributed in the North Pacific.

Scaphocalanus echinatus Farran

(Fig. 123, a–m)

Scaphocalanus echinatus, Farran, 1905, p. 37, pl. 6 and 7; 1929, p. 250, fig. 17; 1937, p. 98; Mori, 1937, p. 50, pl. 24, figs. 12–16.

Female. Length, 1.84–2.48 mm. The cephalothorax and abdomen are in the proportional lengths as 79 to 21. The cephlothorax elongate ovate. (fig. a). The last two thoracic segments are incompletely separated. The lateral corner of the last thoracic segment rounded (fig. d). The rostral filaments are long and slender (fig. c).

The abdominal segments and furca in the proportional lengths:

Segment	Abd. 1–2	3	4	5	Furca	
	32	21	20	10	17	=100.

The genital segment as long as wide, produced slightly below. The furcal rami 2 times as long as wide.

The 1st antenna broken off in distal segments. The 2nd antenna has the exopod about 1.4 times a long as the endopod. The mandible has the exopod about as long as the endopod. The 1st maxilla as figured by Farran. The 2nd maxilla has 3 long vermiform and 5 bud-like filaments on the distal segment; the setae on the 4th and 5th lobes are slender (fig. e). In the maxilliped two basal segments are of about equal lengths; the 1st segment has a bud-like sensory filament on the anterior margin about the middle of the segment.

The 1st leg has a small outer edge spine on the 2nd segment of the exopod. The 2nd leg has a long and curved outer edge spine on the 1st segment of the exopod. The terminal spine of the exopod has 20 teeth (fig. f).

In the 5th pair of legs the inner marginal spine is about 1.5 times as long as the terminal one, and is furnished with about 9 teeth on the outer margin (fig. h). The 5th legs are variable in structure as shown in the figure (fig. i, j). Some specimen has a rudimentary endopod, and the terminal spine is much shorter than the segment itself.

Male. Length, 1.26–1.34 mm. The cephalothotax and abdomen are in the proportional lengths as 72 to 28.

The abdominal segments and furca are in the proporitional lengths:

Abd. 1	2	3	4	5	Furca	
14	23	21	28	3	11	=100.

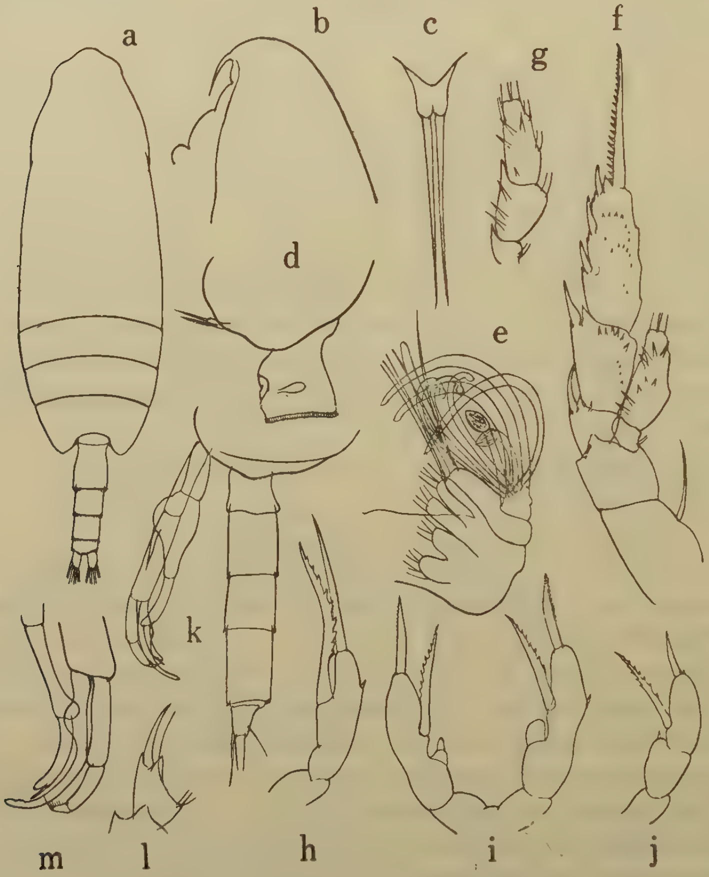

Fig. 123. *Scaphocalanus echinatus* FARRAN.
Female: a, dorsal aspect; b, head, lateral aspect; c, rostrum; d, last thoracic segment, lateral aspect; e, 2nd maxilla; f, 2nd leg; g, endopod of 3rd leg; h, 5th leg: i, 5th pair of legs, other specimen; j, 5th leg; another specimen. Male: k, last thoracic segment and abdomen, lateral aspect; l, 1st segment of exopod of 2nd leg; m, distal segments of 5th pair of legs.

The 1st antenna 20-jointed on the left side, 19-jointed on the right side. They extend to the distal margin of the 2nd abdominal segment. The segments are in the following proportional lengths:

Segment	1	2	3	4	5	6	7	8–9–10–11–12	13	14
	58	62	40	26	31	25	31	128	26	36
	15	16	17	18	19	20–21	22	23	24–25	
	40	53	58	58	62	66	44	71	48	=1.000.

In the 2nd leg the outer edge spine on the 1st segment of the exopod is slender and curved (fig. l). The terminal spine of the exopod has about 40 teeth.

The 5th pair of legs reaches back to the distal end of the 4th abdominal segment (fig. k). The exopod of the right leg 3–jointed, but the distal segment is very small and is represented by a slender proces. The endopod of the left leg 1–jointed.

Remarks. The male has in the 2nd leg a long and curved outer edge spine on the 1st segment of the exopod just as is found in the female.

Occurrence. The species is a common in the deep water of the Izu region. Many females and 2 males were found in the collection.

Distribution. It has been recorded from the Atlantic Slope, New Zealand, Great Barrier Reef of Australia, and Japanese waters.

Scaphocalanus curtus FARRAN

(Fig. 124, a–h)

Scolecithrix curta, FARRAN, 1926, p. 259, pl. 7; 1929, p. 250.

Female. Length, 1.45–1.76 mm. The cephalothorax and abdomen are in the proportional lengths as 75 to 25. The head fused with the 1st thoracic segment. The last two thoracic segments are incompletely separate (fig. a). The postero-lateral margin of the last thoracic segment buntly angular in lateral view (fig. b). The rostral filaments long and slender.

The abdominal segments and furca are in the following proportional lengths:

Segment Abd. 1–2	3	4	5	Furca
34	20	20	10	16 =100.

The furcal rami 2 times as long as wide.

The terminal segments of the 1st antenna missing in the specimen dissected.

The 2nd antenna has the endopod slightly longer than the exopod. The mandible, maxillae, and maxilliped as those of the other members of the genus.

The 2nd leg has a short and curved outer edge spine on the 1st segment of the exopod. The terminal spine of the exopod has 21 teeth (fig. d). The 4th leg has 19 teeth on the terminal spine of the exopod. The posterior surface of the exopod and endopod of the 2nd to 4th legs are furnished with rows of minute spines.

The 5th pair of legs entirely absent.

Male. Length, 1.90 mm. The cephalothorax and abdomen are in the proportional lengths as 64 to 36 (fig. e).

The abdominal segments and furca are in the proportional lengths:

Segment	Abd. 1	2	3	4	5	Furca	
	8	37	22	22	5	8	=100.

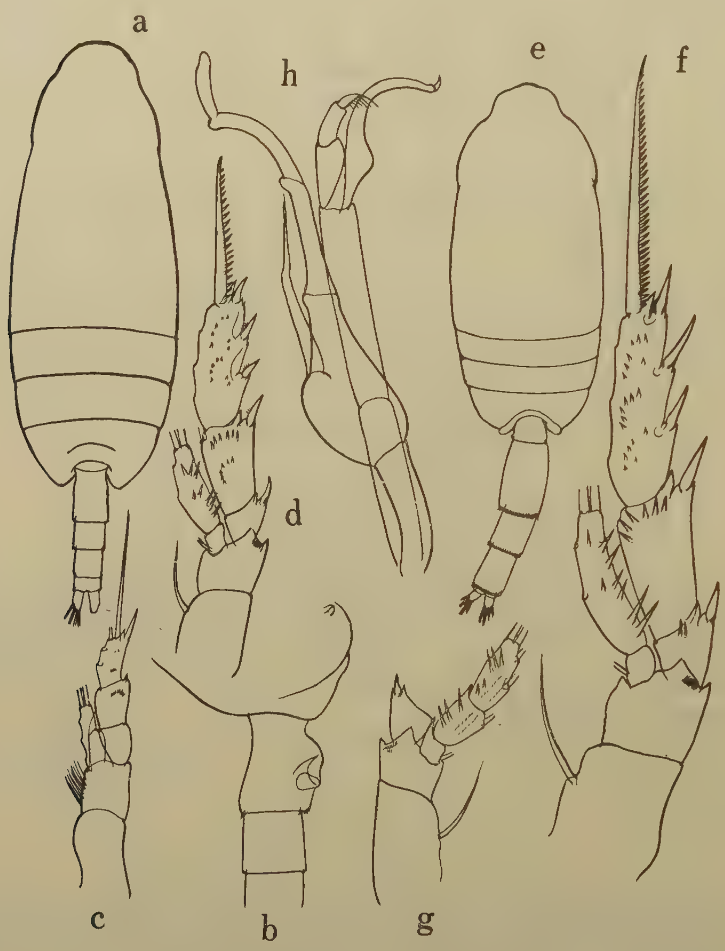

Fig. 124. *Scaphocalanus curtus* FARRAN.
Female: a, dorsol aspect, b, last thoracic segment, lateral aspect; c, 1st leg; d, 2nd leg. Male: e, dorsal aspect; f, 2nd leg; g, 3rd leg; h, 5th pair of legs.

The 1st antenna 20-jointed on the left, 19-jointed on the right side, extend to the end of the thoracic segment. The segments are in the following proportional lengths:

Segment	1	2	3	4	5	6	7	8–9–10–11–12	13	14
	68	95	47	32	32	24	32	119	24	36

	15	16	17	18	19	20	21	22	23	24–25	
	36	47	47	52	47	32	44	40	67	70	=1.000.

In the 2nd leg the outer edge spine on the 1st segment of the exopod straight and short, not reaching the middle of the outer margin of the following segment. The terminal spine of the exopod has about 34 teeth (fig. f).

The 5th pair of legs reaches back to the middle of the 3rd abdominal segment. The right leg has a long endopod. The distal end of the 1st segment of the exopod not produced. The left leg has a short exopod. The endopod 2–jointed. The proximal segment swollen near the proximal (fig. h).

Remarks. The female specimen is easily recognized by the absence of the 5th pair of legs. The male specimen is larger in size than the female, and has a short outer edge spine on the 1st segment of the exopod which corresponds fairly well with that of the female. The species agrees with *Racovitzanus levis* TANAKA in having no 5th pair of legs in the female, which will be described in the following.

Occurrence. 5 females and 2 males from deep water of Sagami Bay.

Distribution. The female specimen has been recorded from the Bay of Biscay and off New Zealand by FARRAN. The species appears to have a fairly wide distribution in the oceans.

Genus *Racovitzanus* GIESBRECHT

The genus was established by GIESBRECHT to accomodate *Racovitzanus antarcticus* collected in the "Belgica" Expedition to the Antarctic. The genus has comprised *R. antarcticus* GIESBRECHT, *R. prorrecta* (GIESBRECHT), and *R. pacificus* (ESTERLY). In the present collection two species *R. porrecta* and *R. levis* were taken, of which the latter appears to be undescribed. BRODSKY (1950) has recorded *R. antarcticus*, *R. pacificus*, and *R. porrecta* from the waters of the Far-eastern and Polar Seas of the U.S.S.R.

The genus *Racovitzanus*, though closely allied to *Scaphocalanus* in the structure of the male 5th pair of leg, comes near to *Scolecithrix* or to *Scolecithricella* in having a rather long outer edge spine on the 2nd segment of the exopod of the 1st leg. The genus is intermediate between *Scaphocalanus* and *Scolecithrix*.

Racovitzanus levis sp. nov.

(Fig. 125, a–m)

Female. Length, 1.95–2.00 mm. The cephalothorax and abdomen are in the proportional lengths as 72 to 28. The cephalothorax elongate ovate, 3 times as long as it is wide at the 1st thoracic segment. The head fused with the 1st thoracic segment. The last two thoracic segments are incompletely fused (fig. a).

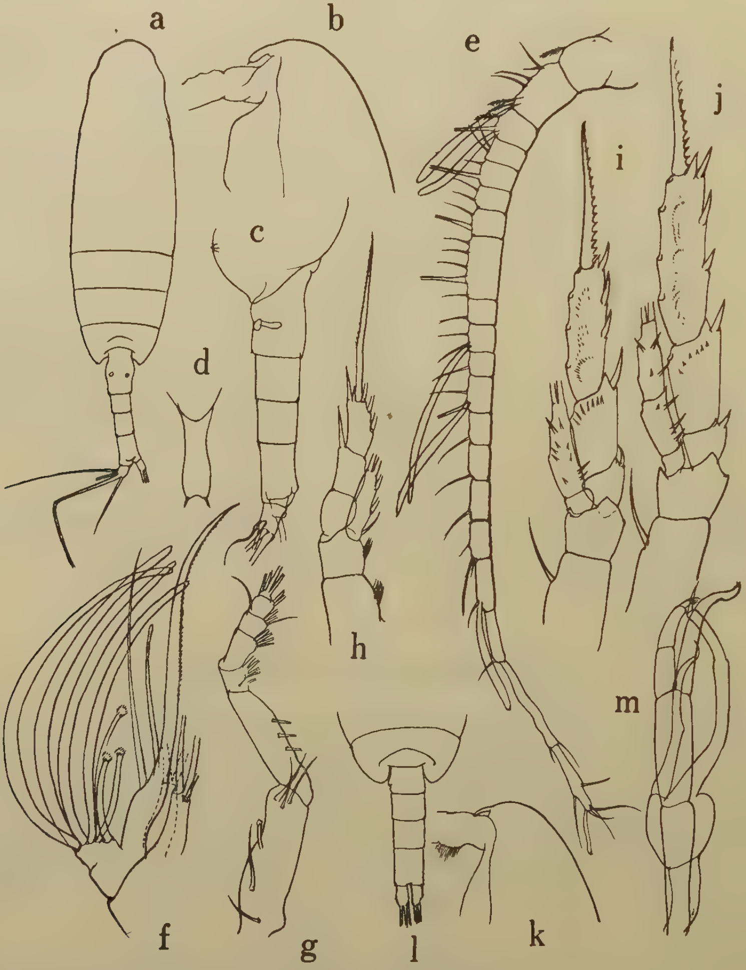

Fig. 125. *Racovitzanus levis* sp. nov.
Female: a, dorsal aspect; b, head, lateral aspect; c, last thoracic segment and abdomen, lateral aspect; d, rostrum; e, 1st antenna: f, 2nd maxilla; g, maxilliped; h, 1st leg: i, 2nd leg; j, 3rd leg. Male: k. head lateral aspect; l, last thoracic segment and abdomen, dorsal aspect; m, 5th pair of legs.

The lateral distal corner of the last thoracic segment bluntly produced (fig. c). The rostrum sausage-shaped, slightly bifurcate at the distal end to which 2 small spines are attached (fig. b, b).

The abdomen 4–segmented. The segments and furca are in the proportional lengths:

Segment	Abd. 1–2	3	4	5	Furca	
	26	16	14	21	9	=100.

The furcal rami asymmetrical, the left side is much larger than the right (9:7). The 2nd inner furcal seta of the left side is much longer than the total length of the body and curved inwardly almost at right angle at the proximal one fifth of the seta.

The 1st antenna 20–jointed, extends to the distal end of the 3rd thoracic segment. The segments are in the dollowing proportional lengths:

Segment	1	2	3	4	5	6	7	8–9–10	11	12	13	14
	49	70	28	28	28	28	32	82	28	31	35	38
	15	16	17	18	19	20	21–22–22	24–25				
	42	49	52	45	59	66	120	93	=1.000.			

a long aesthetaks is found on the segments 2, 3, 12, 14, 19, and 25 (fig. e).

The 2nd antenna has the endopod about as long as the exopod. The mandible and 1st maxilla as in *Scolecithrix danae* (LUBBOCK). The 2nd maxilla has 4 long vermiform and 3 small sheaf-like filaments on the terminal section (fig. f). The maxilliped has a small stalked seta on the middle of the 1st basal segment (fig. g).

The 1st leg has no outer edge spine on the 1st segment of the exopod (fig. h). The 2nd segment of the exopod has a long outer edge spine extending about to the distal end of the 3rd segment of the exopod. The 2nd leg has 3–jointed exopod and 2–jointed endopod. The outer edge spine on the 1st segment of the exopod is small and curved. The posterior surface of the 2nd and 3rd segments of the exopod and the 2nd segment of the endopod have each groups of small spines. The terminal spine of the exopod has 15 teeth (fig. i). The 3rd and 4th legs have each 3–jointed exopod and endopod. The terminal spine of the exopod of the 3rd leg has 12 teeth (fig. j) and that of the 4th leg has 17 teeth. The 4th leg has no inner marginal seta on the 1st basal segment.

The 5th pair of legs eompletely absent.

Male. Length, 1.75 mm. The cephalothorax and abdomen are in the proportional lengths as 75 to 25. General appearance as in the female (fig. k). The abdominal segments and furca are in the proportional lengths:

The 1st antenna 20–jointed, extends to the distal end of the thorax. The segments are in the following porportional lengths:

Segment	Abd. 1	2	3	4	5	Furca	
	21	19	19	26	2	13	=100.

The 1st antenna 20–jointed, extends to the distal end of the thorax. The segments are in the following proportional lengths:

Segment	1	2	3	4	5	6	7	8–9–10	11–12–13	14
	46	66	33	33	33	33	39	72	78	33

15	16	17	18	19	20	21	22	23	24–25	
33	39	72	66	59	59	65	33	52	66	=1.000.

The 1st segment is furnished with a row of long hairs on the posterior margin.

The 2nd antenna has the endopod longer and wider than the exopod. The other mouth organs are less developed.

The 1st to 4th legs as in the female. The terminal spine of the exopod of the 2nd leg has 19 teeth.

The 5th pair of legs resembles that of the male of *Scaphocalanus*. It extends to the distal end of the furca when reflexed. The endopod of the right leg long, slightly exceeds the distal margin of the 1st segment of the exopod of the left leg. The endopod of the left leg is longer than the 3-jointed exopod (fig. m).

Remarks. The female is characterized by the absence of the 5th pair of legs. The male 5th pair of legs has a general resemblance to that of *Scaphocalanus*.

Occurrence. 2 females from Suruga Bay, and one male from Sagami Bay in the hauls from the depth 1000 m to the surface.

Distribution. Northwestern Pacific (present record).

Racovitzanus porrecta (GIESBRECHT)

(Fig. 126, a–i)

Scolecithrix porrecta, GIESBRECHT, 1892, p. 266,, pl. 13, fig. 4, 41, pl. 37, fig. 11; GIESBRECHT und SCHMEIL, 1898, p. 45; *Racovitzanus prorrecta*, BRODSKY, 1950, p. 274, fig. 185; *Racovitzanus nanus*, TANAKA, 1953, p. 132.

Female. Length, 2.07 mm. The cephalothorax and abdomen are in the proportional lengths as 70 to 30. The cephalothorax elongate ovate. The head fused with the 1st thoracic segment. The last two thoracic segments are incompletely separate (fig. a). The lateral distal corner of the last thoracic segment acutely pointed at the apex (fig. c). The rostrum moderately long, bifid at the apex (fig. b, d).

The abdomen 4-segmented. The proportional lengths of the segments and furca:

Segment	Abd. 1–2	3	4	5	Furca	
	28	17	17	27	17	=100.

The genital segment not swollen below. The furcal rami asymmetrical, the left side is much longer and wider than the right. The furcal setae broken off, but the 2nd inner seta may be long as in the foregoing species.

The 1st antenna broken off in the distal segments. The proximal 15 segments are in the following proportions:

Segment	1	2	3	4	5	6	7	8–9–10	11	12	13	14	15
	10	12	5	4	5	5	5	13	5	5	6	6	6

The 2nd antenna has a slender exopod and endopod. The exopod is a little shorter than the endopod. The mandible has a small endopod, about 2/5 as long as the exopod (fig. f). The 1st maxilla has 7 long and 2 short setae on the outer lobe, 5 setae on the exopod, 5+3 setae on the endopod, 2 setae on the 2nd basal segment (fig. e). The 2nd maxilla has 5 long vermiform filaments and 3 short ones on the distal segments. The maxilliped as in the foregoing species.

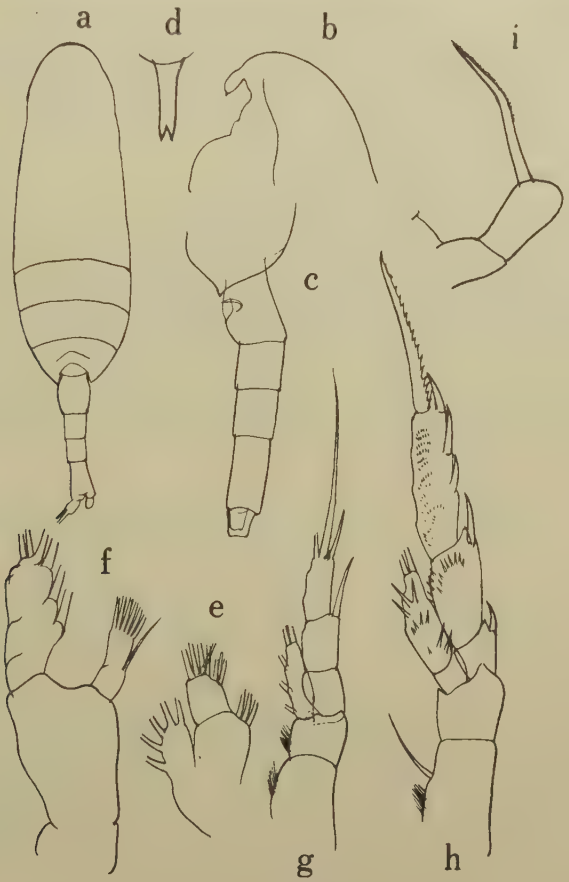

Fig. 126. *Racovitzanus porrecta* (GIESBRECHT). Female: a, dorsal aspect; b, head, lateral aspect; c, last thoracic segment and abdomen, lateral aspect; d, rostrum; e, distal part of 1st maxilla; f, mandible palp; g, 1st leg; h, 2nd leg; i, 5th leg.

The 1st leg is slender (fig. g). The outer edge spine on the 1st segment of the exopod absent; that of the 2nd segment is long and reaches the distal margin of the 3rd segment of the exopod. The inner marginal seta on the distal margin of the 2nd basal segment is absent. The 2nd leg has 3-jointed exopod and 2-jointed endopod. The outer edge spine on the 1st segment of the exopod is short and curved, about 1/3 the length of the outer margin of the following segment. The terminal spine of the exopod has 17 teeth. The posterior surface of the 2nd and 3rd segments of the exopod and 2nd segment of the endopod are furnished with groups of small spines, which are more dense than in the foregoing species (fig. h). The 3rd and 4th legs have each 3-jointed exopod and endopod. The left 3rd leg was abnormal in structure in the specimen dissected: it is composed of 2-jointed exopod and 3-jointed endopod.

The 5th pair of legs 2-jointed. The distal segment has a long serrated seta on the inner distal corner (fig. i).

Remarks. The present specimen is much smaller in size than that described by GIESBRRENCHT. The species is identical with *R. nanus* TANAKA listed in 1953.

Occurrence. One adult female from Suruga Bay in the hauls from deep water, Nov. 1938.

Distributions. The species has been recorded from the Pacific by GIESBRECHT (3°S, 99°W), WILSON (40°N), and BRODSKY.

PALINURID AND SCYLLARID LOBSTERS (CRUSTACEA DECAPODA) FROM NEW CALEDONIA[1,2]

EIJI HARADA

Seto Marine Biological Laboratory, Sirahama

With Plate VI and 3 Text-figures

The Palinurid and Scyllarid lobsters, obtained during the Melanesia Expedition of the Ôsaka Museum of Natural History in 1958, were sent to me for examination through the kindness of Dr. T. TOKIOKA of our Laboratory. This collection comprises only three species, *Scyllarides squamosus* (H. MILNE EDWARDS), *Parribacus caledonicus* HOLTHUIS and *Panulirus penicillatus* (OLIVIER), the second of which has just been described by Dr. L. B. HOLTHUIS (1960) as a new species from the same locality.

Scyllarides squamosus (H. MILNE EDWARDS)

(Text-fig. 1)

Material: a carapace fragment of unknown sex, stranded at Poum (carapace length approximately 55 mm).

The carapace is covered with coarse tubercles and has three protuberances, the anterior one of which is situated on the dorsal side of the rostrum. Three spines are present on the dorsal edge of the orbit. The antennular tergum is provided with two sharp spines at the median of the anterior edge, which are projecting out obliquely upwards. The inner edges of the 1st to 3rd segments of the antenna are erected upwards and are furnished with sharp spines. The anterior margin of the 2nd segment of the antenna is serrated, but without any large teeth. A spinous process is present at the middle of the dorso-anterior margin of the 1st segment of the antenna. The epistome has two pairs of strong teeth near the middle of its anterior edge.

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1) Scientific Results of the Melanesia Expedition No. 10.

2) Contributions from the Ôsaka Museum of Natural History, No. 70 and Contributions from the Seto Marine Biological Laboratory, No. 364.

Publ. Seto Mar. Biol. Lab., IX (1), 1961. (Article 10)

This specimen resembles closely *Scyllarides squamosus* (H. MILNE EDWARDS) from the Japanese waters, but, in the former, the tubercles and bosses on the carapace are a little rougher and stronger, spines on the inner margins of the antennal segments are sharper, and a tooth situated near the inner dorso-anterior corner of the 2nd segment of the antenna is less conspicuous than in the latter.

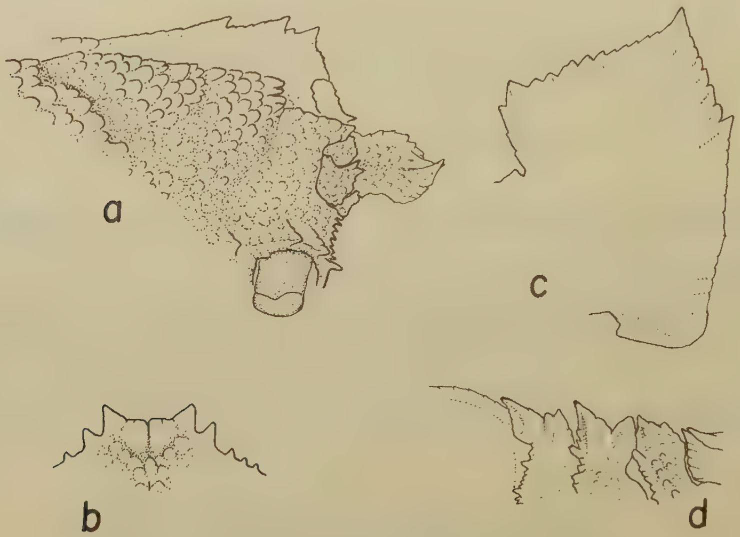

Fig. 1. *Scyllarides squamosus* (H. MILNE EDWARDS).
a, dorso-lateral view of the anterior part of the carapace; *b*, ventral view of the epistome; *c*, dorsal view of the 2nd segment of the antenna; *d*, dorso-lateral view of the inner edges of the antennal segments.

Parribacus caledonicus HOLTHUIS

(Text-fig. 2; Pl. VI)

Material: 1 female (carapace length 37 mm) from Ilot Maitre; 1 male (carapace length 48 mm) and 1 female (carapace length 38 mm) from Ile des Pins; 1 male (carapace length 36 mm) from the Outer Reef of Ile des Pins.

The carapace is broadest at the level of the 3rd or the 4th lateral tooth. The ratio of the total length* of the carapace to its width is approximately 2/3. The dorsal surface of the carapace is hairy. The incision between the two antero-lateral teeth of the carapace is shallow. The rostrum is provided with a short tubercular spinules on its dorsal side. Heavy squamiform sculpturing is present on the abdominal tergites. Anterior parts of the 2nd to 4th abdominal tergites are covered with light squamiform sculpturing. The median carina is distinctly

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* The length from the tip of the rostrum to the posterior end of the carapace.

marked out on 2nd and 3rd abdominal tergites. A pair of small spines on the anterior margin of the epistome are rather blunt. The 5th thoracic sternite bears a pair of small tubercular prominences in male. The distal segment of the antenna is armed with 8 teeth on its anterior margin, and the 2nd segment is provided with 7 sharp teeth (the terminal tooth not included) on its lateral margin. These teeth are marked each with a round white spot on both dorsal and ventral sides. A dark blue band is found girding transversely each segment of the pereiopods. Dark blue spots on the ventral surface of the carapace and thoracic and abdominal sternites are rather inconspicuous as compared with those found on *Parribacus japonicus* Holthuis.

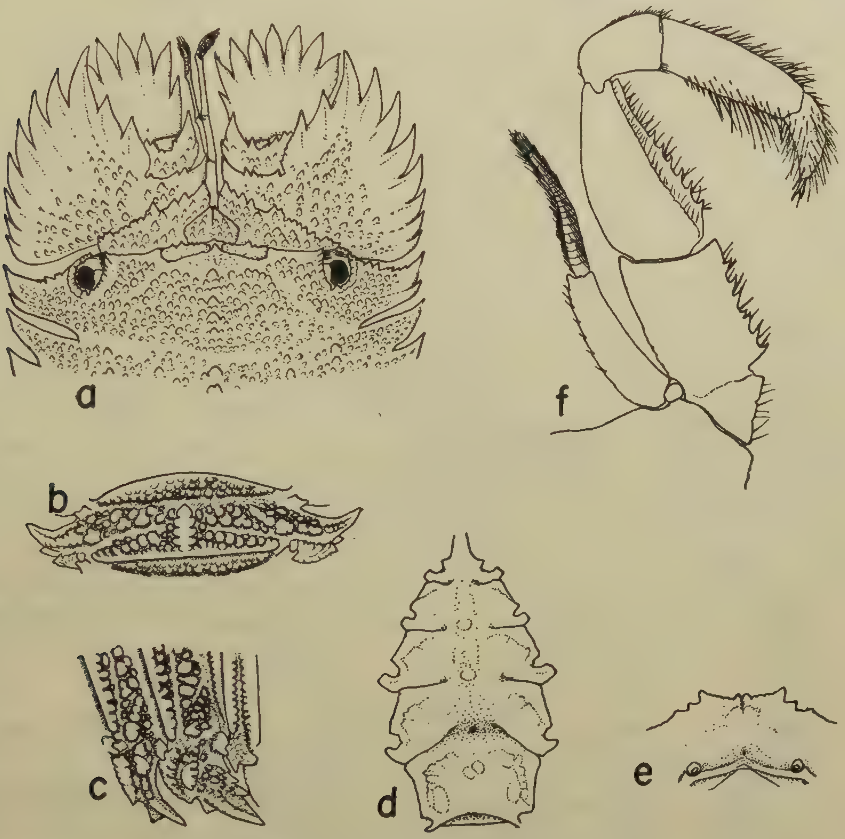

Fig. 2. *Parribacus caledonicus* Holthuis.
a, dorsal view of the antennae and anterior part of the carapace; *b*, dorsal view of the 3rd abdominal segment; *c*, lateral view of the pleurons of 2nd and 3rd abdominal segments; *d*, ventral view of the thoracic sternum (male). (×1.7); *e*, ventral view of the epistome (×1.7); ventral view of the 3rd maxilliped (×4.3).

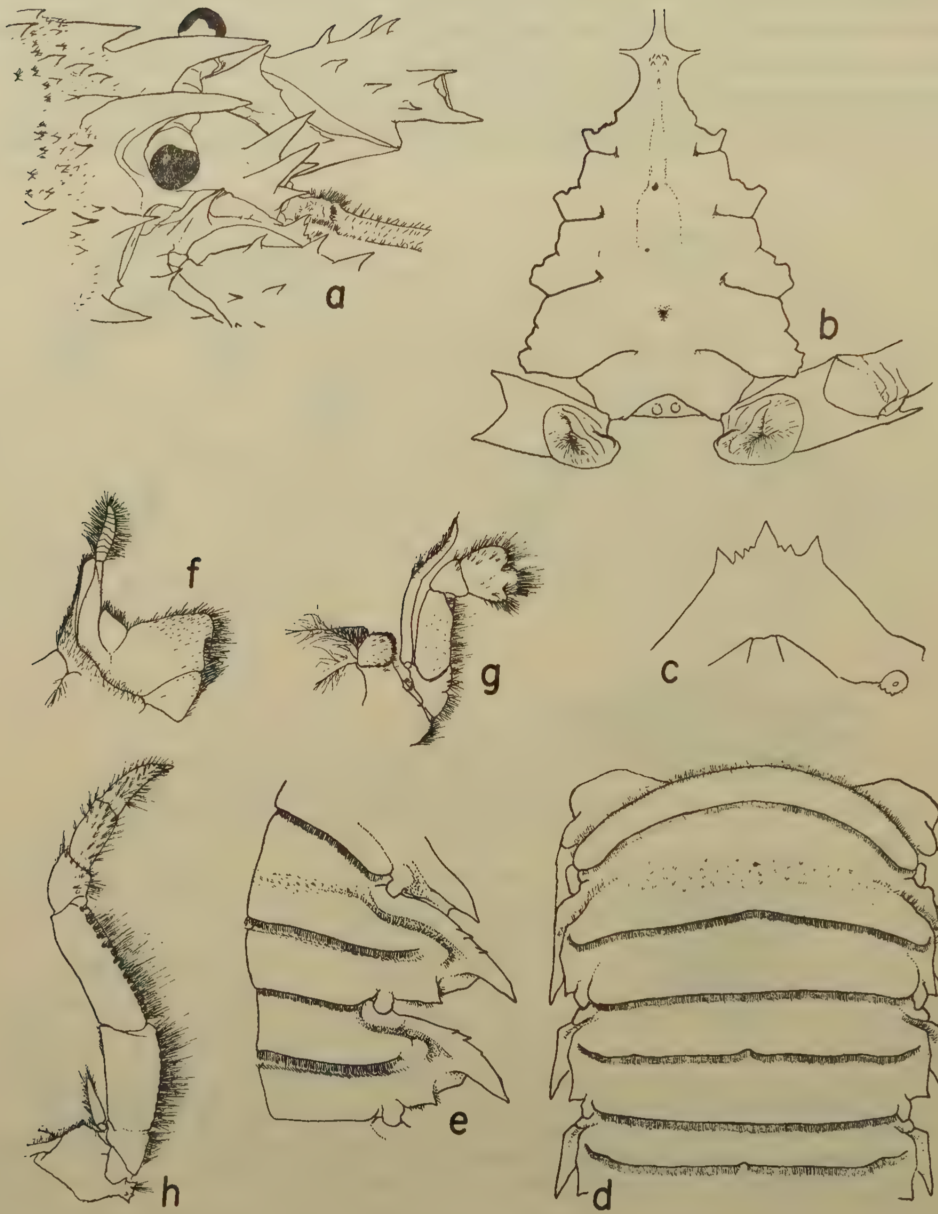

Fig. 3. *Panulirus penicillatus* (OLIVIER).
a, dorso-lateral view of the anterior part of the carapace; *b*, ventral view of the thoracic sternum; *c*, ventral view of the epistome; *d*, dorsal view of the 1st to 4th abdominal segments; *e*, lateral view of the 2nd and 3rd abdominal segments; *f*, ventral view of the 1st maxilliped; *g*, ventral view of the 2nd maxilliped; *h*, ventral view of the 3rd maxilliped.

Panulirus penicillatus (OLIVIER)

(Text-fig. 3)

Material: 1 male (carapace length 89 mm) from the Outer Reef of Ile des Pins; fragments of a carapace of unknown sex, stranded at Moneo.

The carapace is thickly covered with spines and spinules, the latter of which are fringed anteriorly by short stiff hairs. The transverse cervical groove and the transverse groove near the posterior edge of the carapace are both deep. The supraorbital spines are long and strong, and are spaced rather narrowly. Three short spines are present on the median line of the carapace just behind its anterior edge. The antennular tergum bears two pairs of strong spines, of which two on the same side are coalesced at their bases. The dorsal margin of the distal end of the 1st segment of the antenna is armed with a sharp spine and small blunt spinules. The ventral margin of the same part is with blunt spinules. The 1st segment of the antennule, which is twice as long as two following segments, is not longer than half of the carapace length. Transverse grooves on the abdominal tergites are complete and deep, and are concaved slightly forwards. Anterior margins of abdominal tergal lobes bear spinules. The posterior margin of the 6th abdominal tergite is furnished with shap spinules; hairs fringing this part are not so long as in *Panullirus versicolor* (LATREILLE). Spinules on the dorsal surface of the telson are not so sharp as in *Panulirus versicolor* (LATREILLE). The epistome is armed with sharp spinules on its anterior margin. The 5th thoracic sternite is provided with a pair of blunt tubercular protuberances near its posterior margin. The 3rd maxilliped has a short expodite half as long as the ischium. Pereiopods are furnished longitudinally with white stripes.

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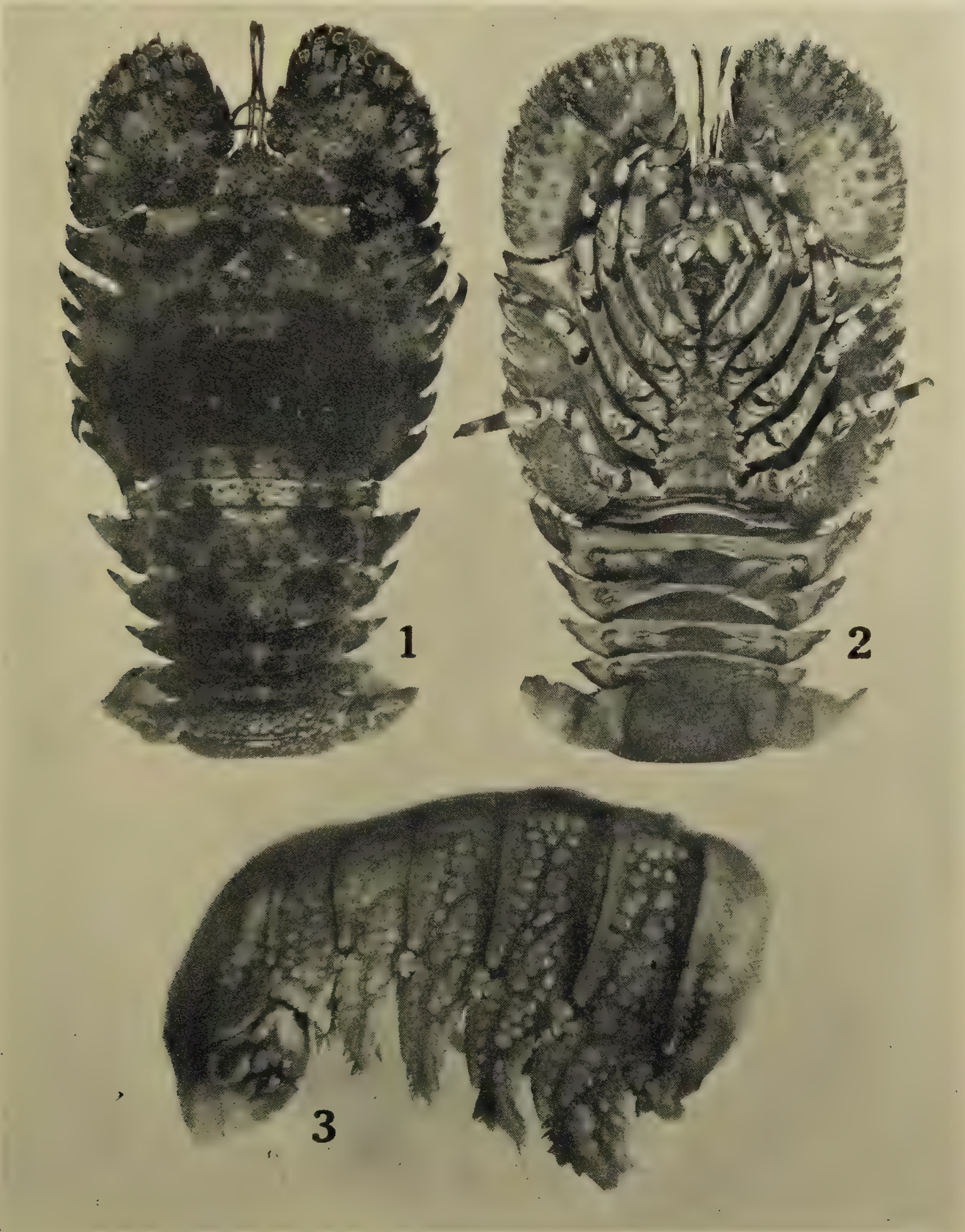
EXPLANATION OF PLATE VI

Parribacus caledonicus HOLTHUIS.

Fig. 1. Dorsal view of a male.

Fig. 2. Ventral view of a female.

Fig. 3. Lateral view of the abdomen of a female.



E. Harada: Palinurid and Scyllarid Lobsters from New Caledonia.

NOTEWORTHY OCTOCORALS COLLECTED OFF THE SOUTHWEST COAST OF KII PENINSULA, MIDDLE JAPAN

PART 2, TELESTACEA, GORGONACEA AND PENNATULACEA[1]

Huzio UTINOMI

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With Plates VII-X and 14 Text-figures

Introduction

The present paper continues the records or descriptions of some noteworthy octocorals found in the offshore bottom samples collected by the bull trawler "Kaiun-maru" in the outer sublittoral region off the southwest coast of Kii Peninsula, mostly from the depths of about 100–200 meters. Therefore, the octocorals herein reported, especially the gorgonaceans, are for the most part fragments or small-sized forms, larger forms being more abundantly found there in shallower waters.

Part 1, which covered the Stolonifera and Alcyonacea, appeared in this journal, Volume VIII, no. 1 (1960). This second part deals with the members of the remaining groups, Telestacea, Gorgonacea and Pennatulacea.

LIST OF THE SPECIES TREATED IN THIS PAPER

Telestacea

1. *Telesto trichostemma* (Dana)
2. *Telesto arborea* Wright & Studer
3. *Paratelesto rosea* (Kinoshita)

Gorgonacea

4. *Parisis minor* Wright & Studer
5. *Acalycigorgia inermis* (Hedlund)
6. *Acalycigorgia irregularis* Kükenthal & Gorzawsky

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[1] Contributions from the Seto Marine Biological Laboratory, No. 365.

Publ. Seto Mar. Biol. Lab., IX (1), 1961. (Article 11)

7. *Acanthogorgia japonica* KÜKENTHAL & GORZAWSKY
8. *Discogorgia dendritica* (NUTTING)
9. *Muricella abnormalis* NUTTING
10. *Muricella nitida* (VERRILL)
11. *Muricella magna* n. sp.
12. *Astrogorgia rubra* THOMSON & HENDERSON
13. *Menella indica* GRAY
14. *Filigella mitsukurii* KINOSHITA
15. *Euplexaura attenuata* (NUTTING)
16. *Chrysogorgia rotunda* KINOSHITA
17. *Plumarella cristata* KÜKENTHAL & GORZAWSKY
18. *Plumarella serta* KÜKENTHAL & GORZAWSKY
19. *Thouarella hilgendorfi* (STUDER)

Pennatulacea

20. *Cavernularia obesa* MILNE EDWARDS & HAIME
21. *Echinoptilum macintoshi* HUBRECHT
22. *Sclerobelemnon burgeri* (HERKLOTS)
23. *Funiculina quadrangularis* (PALLAS)
24. *Stachyptilum dofleini* BALSS
25. *Leioptilus fimbriatus* (HERKLOTS)
26. *Pteroeides breve* KÖLLIKER

TELESTACEA

Family Telestidae H. MILNE EDWARDS

1. *Telesto trichostemma* (DANA), 1846

Gorgonia trichostemma DANA, 1846, p. 665, pl. 59, fig. 3.
Telesto (*Carijoa*) *trichostemma* WRIGHT & STUDER, 1889, p. 264; STUDER, 1889, p. 2, pl. 3, fig. 1a–b; pl. 5, fig. 1; pl. 6, figs. 1–2; THOMSON & HENDERSON, 1905, p. 319.
Telesto trichostemma HICKSON, 1903, p. 481; LAACKMANN, 1909, p. 77; THOMSON & MACKINNON, 1911, p. 692; KÜKENTHAL, 1911, p. 326, text-figs. 42–44, pl. 21, fig. 14; HICKSON, 1921, p. 369; UTINOMI, 1956a, p. 224, fig. 1.

Material. 5 fragments. Off Minabe, 100–200 m. III–1950. M. OZAKI coll.

The specimens are all fragmental, very flabby in texture and dirty white in color. They are as usual covered by an encrusting siliceous sponge (*Prosuberites* after HICKSON) thinly.

Records of occurrence. Widely distributed in the Indo-West Pacific: Fiji Islands (DANA), Torres Straits, 3–11 fms. (WRIGHT & STUDER), Aru Islands (KÜKENTHAL), Australia (THOMSON & MACKINNON), Patani, Siam (THOMSON &

HENDERSON), Maldive Archipelago, 25 fms. (HICKSON), Koror Island, Palau (UTINOMI), Uraga Channel, mouth of Tokyo Bay, 40–200 fms. (HICKSON), Miike Harbour in the Ariake Bay, Kyusyu, intertidal (Unpublished). From these records it seems to occur in shallow seas down to 200 fathoms in depth.

2. *Telesto arborea* WRIGHT & STUDER, 1889

(Fig. 1)

Telesto (*Carijoa*) *arborea* WRIGHT & STUDER, 1889, p. 262, pl. 39, figs. 1–1a; THOMSON & HENDERSON, 1906, p. 433; LAACKMANN, 1909, p. 88, text-fig. G, pl. IV, fig. 6.

Telesto arborea THOMSON & MACKINNON, 1911, p. 692, pl. 67, fig. 2; THOMSON & DEAN, 1931, p. 212, pl. XI, figs. 4 and 6.

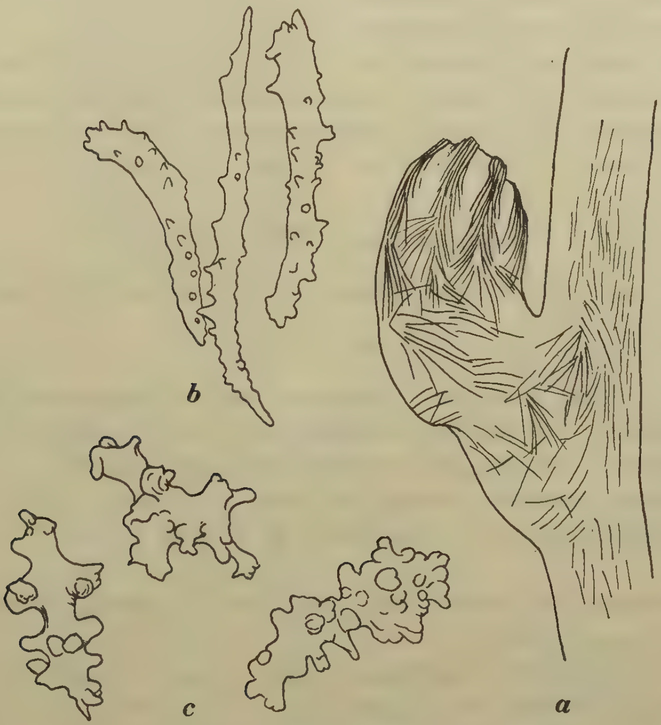

Fig. 1. *Telesto arborea* WRIGHT & STUDER.
a, Lateral polyp; *b*, anthocodial spicules; *c*, spicules from body wall of stem.
〔*a*, ×18; *b*–*c*, ×150.〕

Material. A fragment. Southwest of Minabe, 100–200 m. III–1944. S. SAKAGUCHI coll.

Description. The material consists of a single stem, about 9 cm in length, showing only a trace of branching in the basal part fixed to a shell shingle.

The stem, presumably of a younger stage, is evenly slender and longitudinally ridged in 8 rows closely packed with spicules. The diameter of the stem is approximately 0.7 mm distally and 1.2 mm basally. The distal part of the stem bears only seven lateral polyps, alternately arranging at an interval of about 3–4 mm.

The lateral polyps are all cylindrical, about 3–5 mm long and 1.2 mm wide. They exhibit eight longitudinal ridges where elongate spicules are closely packed together, leaving eight naked furrows between them. These spicules are either slender warty spindles or needles, measuring about 0.18–0.4 mm long and 0.017–0.018 mm wide.

The spicules of the stem wall are shorter but stouter tuberculate spindles or capstans, about 0.1–0.26 mm long and 0.02–0.035 mm wide. There is no sign of fusion between these spicules whatever.

Records of occurrence. Arafura Sea, 49 fms. (WRIGHT & STUDER), Australia (THOMSON & MACKINNON), Maldive Archipelago, 23–25 fms. (HICKSON), Zanzibar, 10 fms. (THOMSON & HENDERSON), Amboina and Sydney (LAACKMANN), Malay Archipelagoes, down to 250 m in depth (THOMSON & DEAN).

3. *Paratelesto rosea* (KINOSHITA), 1909

Telesto rosea KINOSHITA, 1909a, p. 119; KINOSHITA, 1910, p. 209 (partim); KÜKENTHAL, 1913, p. 234 (listed only).

Paratelesto rosea UTINOMI, 1958, p. 93, textfig. 2, pl. 5, figs. 2–4.

Material. 1) Many specimens. Kii-ôsima. 1940. S. SAKAGUCHI coll.

2) 2 specimens. Off Minabe, 100–200 m. III–1944. S. SAKAGUCHI coll.

3) 1 specimen. Mouth of Tanabe Bay, 30 m. 26–IX–1953.

4) Fragments. Mouth of Tanabe Bay, 30 m. 29–IV–1955. T. YAMAMOTO coll.

5) 7 specimens. Mouth of Tanabe Bay, 20–30 m. 18–IV–1957. T. YAMAMOTO coll.

6) 4 specimens. Off Nada, Gobô. prob. 20–30 m. (taken by lobster-net). 27–IV–1958. T. YAMAMOTO coll.

Records of occurrence. Kasiwazima, Prov. Tosa, 80 fms. (type locality), southwest coast of Kii Peninsula (UTINOMI).

GORGONACEA

Suborder SCLERAXONIA

Family Parisididae AURIVILLIUS

4. *Parisis minor* WRIGHT & STUDER, 1889

For description see UTINOMI, 1958, p. 101.

Material. 2 fragments. Off Minabe, 100–200 m. III–1944. S. SAKAGUHI coll.

Records of occurrence. Hitherto known only from Japan : Sagami Bay, 345 fms. WRIGHT & STUDER), Goto Islands, 160 m and Bonin Islands, 80 fms. (AURIVILLIUS), Kasiwazima, Tosa Bay. (UTINOMI).

Another species *Parisis fruticosa* VERRILL, type of the genus, has been found off Nada on April 27, 1958. In this area, this species seems to occur in inshore waters shallower than 50 meters in depth, though often recorded from deeper waters elsewhere.

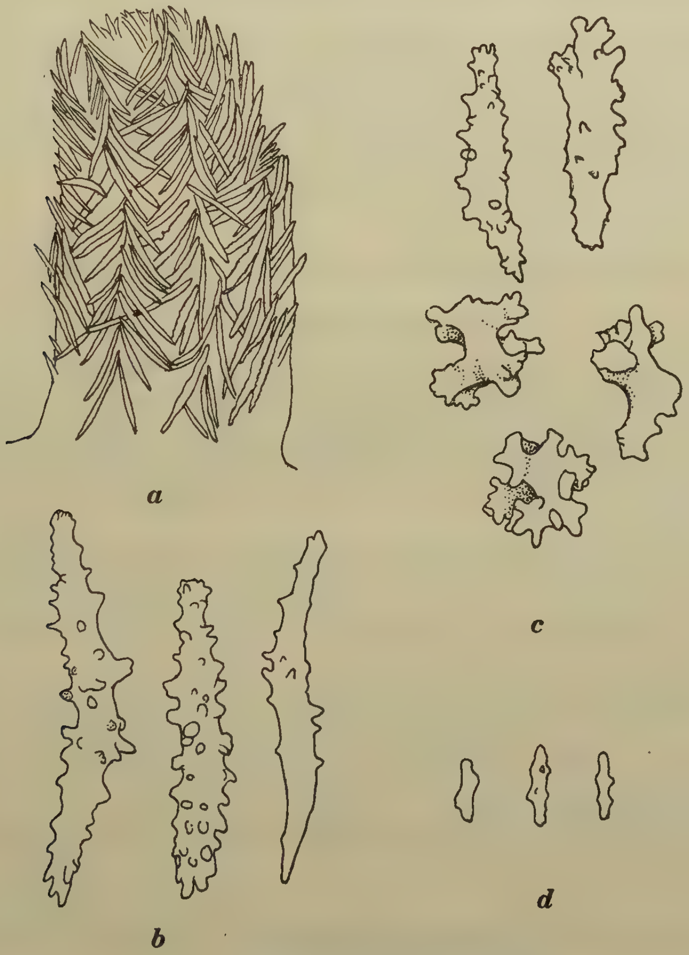

Fig. 2. *Acalycigorgia inermis* (HEDLUND).
a, Details of polyp ; *b*, spicules of calicular wall ; *c*, spicules of stem rind ; *d*, tentacle spicules.
〔*a*, ×18 ; *b–d*, ×150.〕

Suborder HOLAXONIA

Family Acanthogorgiidae GRAY

5. *Acalycigorgia inermis* (HEDLUND), 1890

(Fig. 2)

Acanthogorgia inermis HEDLUND, 1890, p. 6, pl. 2, figs. 1–27.
Acalycigorgia inermis KÜKENTHAL & GORZAWSKY, 1908, p. 49, textfig. 46, pl. 3, fig. 17; KÜKENTHAL, 1909, p. 78; KÜKENTHAL, 1924, p. 239, fig. 139; AURIVILLIUS, 1931, p. 45, pl. 2, fig. 5a–b, textfigs. 8–9; STIASNY, 1947, p. 23 (listed only); UTINOMI, 1954, p. 104.

Material. One specimen. Off Minabe, 100–200 m. III–1944. S. SAKAGUCHI coll.

Records of occurrence. Distrbuted all along the pacific coasts of southern Japan, from Sagami Bay (KÜKENTHAL & GORZAWSKY) to Hongkong (HEDLUND), rather commonly on shallower basin than on offshore basin. At living state, the extended polyps are beautifully colored purple.

6, *Acalycigorgia irregularis* KÜKENTHAL & GORZAWSKY, 1908

(Pl. VII, fig. 1)

Acalycigorgia irregularis KÜKENTHAL & GORZAWSKY, 1908, p. 42, textfigs. 38–40, pl. 3, fig. 15; KÜKENTHAL, 1924, p. 238, fig. 138; STIASNY, 1947, p. 23 (listed only).

Material. One specimen. Off Tanabe Bay. II–1949. Collector unrecorded.

Description. The specimen is small, about 9 cm high, branched irregularly, almost in one plane.

The axis with a membranously expanded base is uniformly slender, brownish in color and issues alternately primary branches, and then a few secondary branches. The polypiferous branches are slender all throughout, about 2 mm in diameter.

The polyps are all small, closely disposed on all sides of the axis. They are consticted at tip and usually wider than high at a contracted state, showing a diameter of about 1 mm. The spicules are generally smaller than those of the preceding *inermis*.

Record of occurrence. Hitherto known only from the type locality (Sagami Bay).

7. *Acanthogorgia japonica* KÜKENTHAL & GORZAWSKY, 1908

(Pl. VII, fig. 2)

Acanthogorgia japonica KÜKENTHAL & GORZAWSKY, 1908, p. 53, textfigs. 47–50, pl. 3, fig. 18; KÜKENTHAL, 1924, p. 249, fig. 143.
Paracanthogorgia japonica STIASNY, 1947, p. 59 (listed only).

Material. 1) A fragment. Off Minabe. II–1949. Collector unrecorded.

2) One specimen. Off Minabe. 4–V–1958. K. MIHASI coll.

Description. As shown by a color photograph of a complete colony obtained in Ise Bay (UTINOMI, 1956, pl. 9, fig. 7), the colony is rather ramose, not branching in one plane and dirty yellowish brown in color. The branches arise approximately at right angles and bear many large polyps on all sides. They are about 7–12 mm in diameter, when the polyps around the axis are combined together. Each polyp is about 3 mm high and 1.5 mm wide. The axis is robust, horny and dark brown. Details of the spiculation agree well with the original description.

Record of occurrence. Hitherto known only from the type locality (Sagami Bay, 80–250 m).

Family Paramuriceidae BAYER

8. *Discogorgia dendritica* (NUTTING), 1910

(Fig. 3; pl. VII, fig. 4)

Placogorgia dendritica NUTTING, 1910a, p. 79, pl. 12, figs. 1–1a, pl. 22, fig. 6.
Discogorgia dendritica KÜKENTHAL, 1924, p. 214; BAYER, 1956, p. F 203, fig. 2a–d.

Material. 2 specimens. 23 km west of Setozaki, 80–150 m. 28–XI–1957. E. HARADA coll.

Description. Both specimens, 9 cm and 12 cm respectively in height, are attached by a membranous base to a broken shell, and loosely branched in one plane. The colony is generally pale brown, but the polyps appear purplish brown. The lower part of the main stem and lower branches lacks the calicles, and about 2 mm in diameter.

The calicles are closely arranged in four longitudinal rows, about 2 mm apart, though somewhat twisted here and there.

The individual calicles are rather high cones, averaging about 1.5 mm high and 1.5–1.8 mm in basal diameter. Their walls appear qnite smooth at a glance, but they are really ornamented with small, thorn-scales bearing jagged margins or foliaceous projections, compactly packed together.

The retractile polys rest above the calicles, about 0.5 mm high and 1.2 mm wide, are armed with about 4 or 5 transverse rows of small collaret spicules, 8 points of larger spicules, and each a small intermediate spicule between the points.

In the rind of the basal part of the stem there found no thorn-scales as seen in the calicles and upper rind.

Details of spicules and their measurements (in mm) are:

Calicles and upper rind—thorn-scales of irregular shape, with jagged margins and often foliaceous wide projections. 0.32×0.14, 0.35×0.12, 0.35×0.03, 0.45×0.3

Sterile basal rind and axial sheath—mostly thorny spindles and derivatives.

0.038×0.035, 0.12×0.05, 0.26×0.05, 0.23×0.17, 0.35×0.07

Points and collarets—feebly warted spindles. 0.3×0.03, 0.62×0.08, 0.9×0.09

Tentacles—flattened rods. 0.17×0.01

Record of occurrence. Hitherto known only from the type locality (Kwandang Bay entrance 80 m and Buton Island 75–94 m, Malay Archipelago).

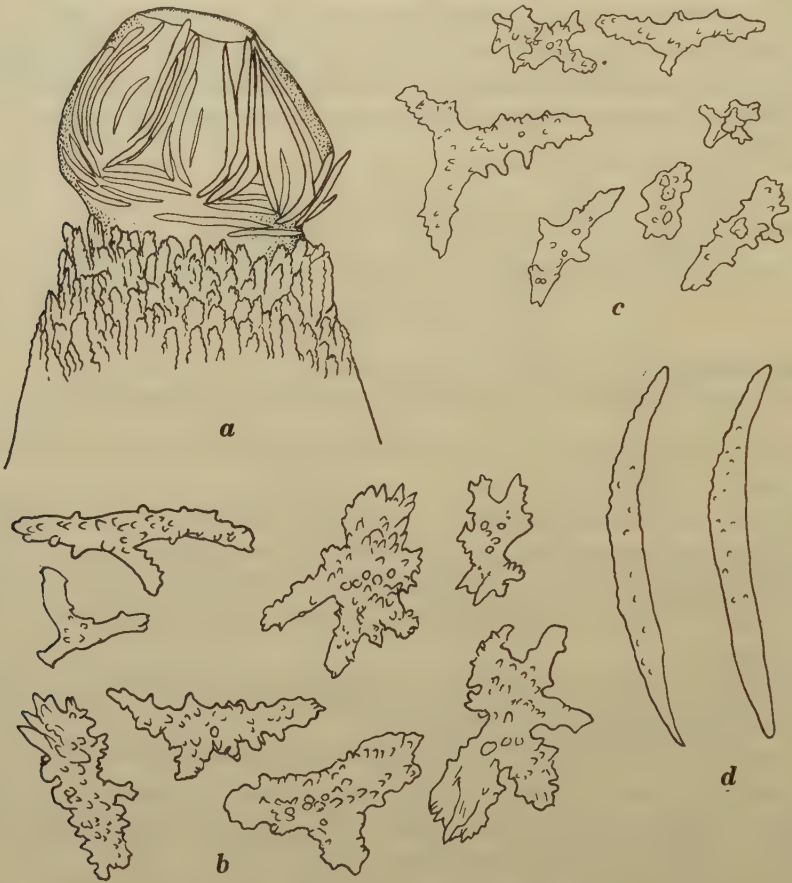

Fig. 3. *Discogorgia dendritica* (Nutting).

a, Tip of calicle with extended polyp; *b*, thorny scales from stem rind and calicular wall; *c*, spicules of various shape from sterile basal part of stem rind; *d*, anthocodial spicules.

〔*a*, ×33; *b*–*d*, ×80.〕

9. *Muricella abnormalis* Nutting, 1912

(Fig 4; Pl. VII, fig. 3)

Muricella abnormalis Nutting, 1912, p. 79, pl. 11, figs. 3–3a, pl. 20, fig. 6; Kükenthal, 1924, p. 174; Bayer, 1956, p. F206, fig. 149 (1).

Material. 1) One broken specimen. Off Minabe, 100–200 m. III–1944. S. SAKAGUCHI coll.

2) One specimen. Off Tanabe Bay. III–1949. Collector unrecorded.

Description. Both specimens are scantily branched in one plane, with a slightly expanded base. They are 6 cm long and 12 cm long respectively. The axis is yellowish brown, rather stout, though slender in branches of a smaller colony.

The cortex is generally thin all throughout and the calicles are scattered on all sides of the stem and branches. The individual calicles vary in size, but a typical one is a low truncated cone, about 2 mm in height and so in diameter. Their walls consist of eight triangles which stand vertically above the spicules of the coenenchyma. Each of the triangles is composed of about 8 spindles converging towards the margin of the calicle and slightly projecting above the upper margin: between them there is a wide naked area above.

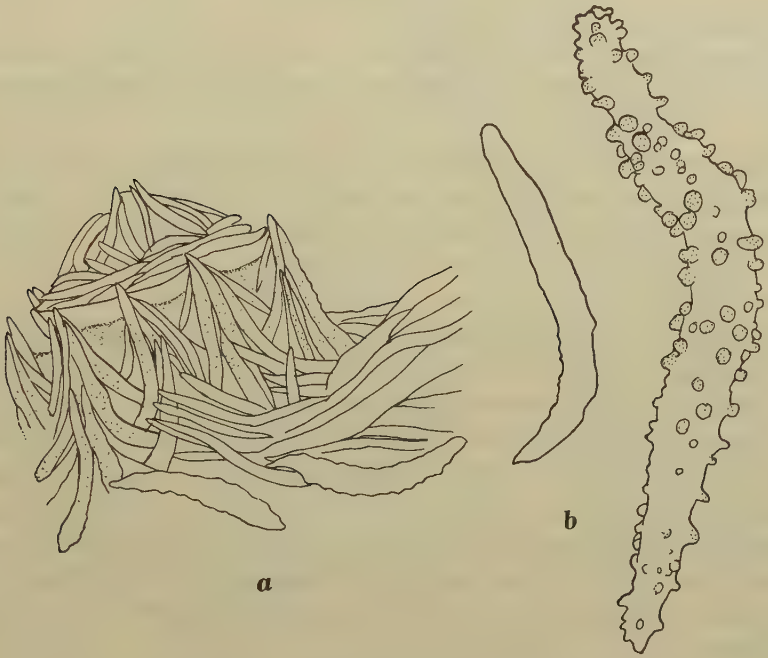

Fig. 4. *Muricella abnormalis* NUTTING.
a, Details of polyp; *b*, anthocodial spicule; *c*, calicular spicule.
〔*a*, ×33; *b–c*, ×80.〕

The polyps, when partially extended or retracted, are rather wider than high and armed with three transverse rows of collaret spindles and eight points each of which is formed of a pair of spindles. Their measurements (in mm) are:

Calicle and cortex—tuberculate spindles. 0.55×0.08, 0.77×0.11, 0.88×0.11, 1.0×0.16

Collarets—nearly smooth spindles. 0.22×0.02, 0.44×0.05, 0.55×0.06

Points—nearly smooth spindles. 0.2×0.02, 0.4×0.05

Record of occurrence. Hitherto known only from the type locality (Osezaki, Suruga Bay, Japan, 108 fms.).

10. *Muricella nitida* (VERRILL), 1868

(Fig. 5; Pl. VIII, fig. 5)

Muricea nitida VERRILL, 1868, p. 412.

Muricella nitida VERRILL, 1869, p. 450; WRIGHT & STUDER, 1889, p. 127; GERMANOS, 1896, p. 181, pl. 10, fig. 4; THOMSON & HENDERSON, 1905, p. 302; THOMSON & SIMPSON, 1909, p. 245 (no new record); KÜKENTHAL, 1924, p. 172, fig. 112.

Material. One specimen. Off Minabe, 100–200 m. III–1944. S. SAKAGUCHI coll.

Description. The specimen consists of the basal part of a colony, about 57 mm in length, with two branches (40 mm long and 65 mm long respectively) arising at right angles from one side of the stem. Each of the two branches bears one branchlet, and they spread in one plane.

The calicles are mostly placed laterally, alternate in position at distances of about 1–3 mm; some of them are sometimes distorted somewhat obliquely to the plane of branching. The individual calicles are usually placed perpendicularly and large, fairly cylindrical in form, about 1.5–2 mm high and 1.2–18 mm in basal diameter. Their walls are filled with red spicules vertically disposed, indistinctly converging into eight point at their tip.

The polyps, when extended, are generally longer than wide and armed with eight points forming of 2 or 3 pairs of white spicules; the collarets at base, however, seem to be indistinct, though some smaller spicules may be obliquely disposed below.

The cortex is rather thick and closely packed longitudinally with stout tuberculate spindles; those on the surface layer are much larger than those of the calicles, bright red in color, while those of the deeper layer are smaller and pink in color. The axis is horny, flexible and yellowish brown.

The measurements of spicules (in mm) are:

Stem cortex—tuberculate spindles, carmin-red in outer layer and pink in deeper layer. 1.2×0.3, 2×0.35

Calicles—tuberculate spindles, carmin-red. 0.5×0.07, 0.7×0.07, 0.8×0.1, 1.0×0.12

Points—tuberculate spindles narrowing downwards, yellowish or pure white. 0.6×0.06, 0.7×0.07, 0.8×0.1

Tentacles—curved rods, colorless. 0.12–0.15 long

Records of occurrence. Ebon Island in the Central Pacific (type locality); Sagami Bay, 345 fms., Japan (WRIGHT & STUDER); Ternate Inland, Malay Archipelago (GERMANOS): Ceylon Seas (THOMSON & HENDERSON).

Remarks. As to the coloration of *Muricella nitida* (VERRILL), the present specimen differs somewhat from the notes given by earlier authors, viz. the calicles and coenenchyma are reported as purplish red (VERRILL), coral red (WRIGHT & STUDER: THOMSON & HENDERSON) or yellowish red (GERMANOS). However, color is not always a reliable feature since it may vary within the species, sometimes due to longterm preservation, but is a useful secondary character.

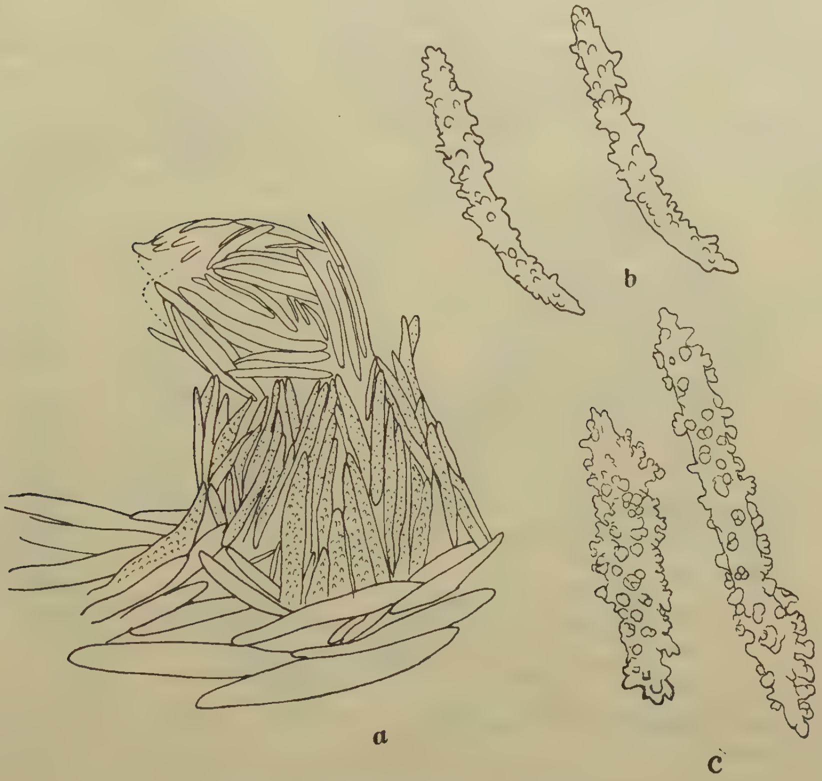

Fig. 5. *Muricella nitida* (VERRILL).
a, Details of calicle and extended polyp; *b*, anthocodial spicules; *c*, calicular spicules.
[*a*, ×18; *b*–*c*, ×80.]

11. *Muricella magna* n. sp.

(Fig. 6; Pl. VIII, figs. 6–7)

Material. One specimen (SMBL Type 185). Off Minabe, 100–200 m. III–1944. S. Sakaguchi coll.

Description. This new species is represented by a beautiful nearly unbranched colony, light purplish red in color.

The colony, about 10 cm in total height, is nearly unbranched, bearing only three short branchlets near the distal part, about 6 mm, 7 mm and 25 mm respectively in length. The base of the main stem is expanded with a spread of about 1 cm across. For a distance of about 1 cm just above the basal disk, the stem is cylindrical, with a diamer of about 4 mm and devoid of calicles. In the remaining part of the stem and branchlets, the coenenchyma is flattened in the plane of branching, and their terminal ends are thickened with 3 calicles.

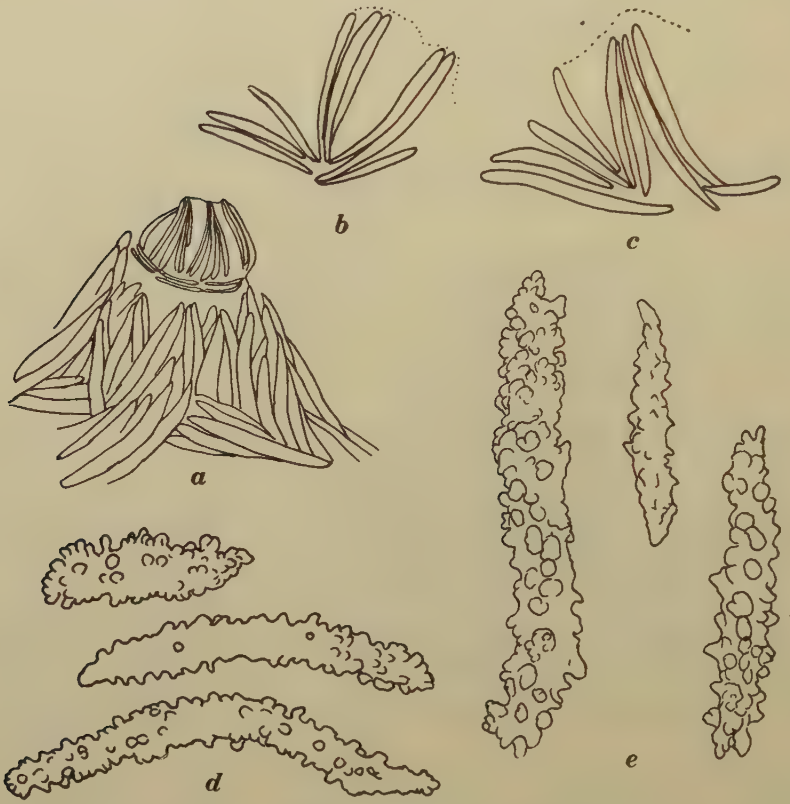

Fig. 6. *Muricella magna*, n. sp.
a, Details of polyp and calicle; *b–c*, arrangement of anthocodial spicules; *d*, anthocodial spicules; *e*, calicular spicules.
〔*a*, ×12; b, ×25; *c*, ×33; d–e, ×80.〕

The coenenchyma is fairly thick and compactly filled with light purplish red tuberculate spindles. The calicles are irregularly distributed on all sides of the coenenchyma, usually 2 mm apart. The individual calicles are quite large, crater-like in form, with a round opening, about 1.5 mm in height and 3 mm in diameter at tip. Their walls are gradually sloped around and filled with spindles similar to those of the coenenchyma, distinctly converging into eight points at tip.

The polyp body is armed with vertical spindles, forming an eight-pointed prominent operculum. The collaret is formed of only two circlets of spindles which are obliquely or transversely disposed below the operculum. These polypal spicules are heavily tuberculate spindles bluntly ended and colored light purplish red like those of the calicles. The retractile neck portion of the polyps is also furnished with a number of pinkish rodlets.

The axis is rather robust, horny, brown in color, and 1 cm in diameter at the end of the branchlets.

Measurements of spicules (in mm) are:

Calicles—tuberculate spindles, roundly ended, light purplish red. 0.5×0.06, 0.7×0.2, 0.8×0.1, 0.8×0.1, 1.35×0.3

Points—tuberculate spindles, curved and roundly ended, light purplish red. 0.18×0.035, 0.26×0.05, 0.35×0.06, 0.4×0.07

Tentacle—curved rod, colorless. 0.1–0.2 long

Neck portion of polyp—slender rodlets or spindles, pinkish. 0.07×0.03, 0.1×0.01, 0.17×0.02

Remarks. The present specimen is apparently related to *Muricella rubra* THOMSON and *M. perramosa* RIDLEY in coloration, but differs from them in the scanty branching, the polypal arrangement and the thick flattened coenenchyma.

12. *Astrogorgia rubra* THOMSON & HENDERSON, 1906

(Fig. 7; Pl. VIII, fig. 8)

Astrogorgia rubra THOMSON & HENDERSON, 1906, p. 69, pl. 5, fig. 10; KÜKENTHAL, 1924, p. 235, fig. 137.

? *Callistephanus koreni* THOMSON & HENDERSON, 1906, p. 79.

Material. A portion of a reddish colony. Off Minabe, 100–200 m. III–1944. S. SAKAGUCHI coll.

Description. The specimen is represented only by a part of a beautiful coral red colony, about 4 cm long, missing both ends. Superficially it resembles *Callistephanus* (=*Swiftia*) *koreni* WRIGHT & STUDER of the Paramuriceidae or *Nicella*-species of the Ellisellidae, but may be referable to *Astrogorgia rubra* THOMSON & HENDERSON, previously known only from the type locality.

The coenenchyma is uniformly coral red in color, granular on surface and fairly thick. The stem is somewhat flattened and the verrucae are arranged alternately on lateral sides, the distance between two verrucae on the same side being about 2–3 mm, but some of the verrucae are somewhat turned to the other sides. The diameter of the stem where the verrucae are absent is about 1.5 mm.

The verrucae are dome-shaped, about 1.3–2 mm across at apex and about 1 mm in height. Their apical margin is marked by eight obtuse points.

The coenenchyma is fairly thick and its surface is thickly covered by small warty spindles or clubs, about 0.09×0.05 mm, perpendicularly to the surface, giving the surface a granular appearance. The inner spicules arranged longitudinally are rather longer warty spicules, or sometimes club-like gradually tapering to one end. These spicules are all coral red and measure in mm:

0.07×0.02, 0.12×0.05, 0.16×0.035, 0.18×0.035, 0.19×0.07

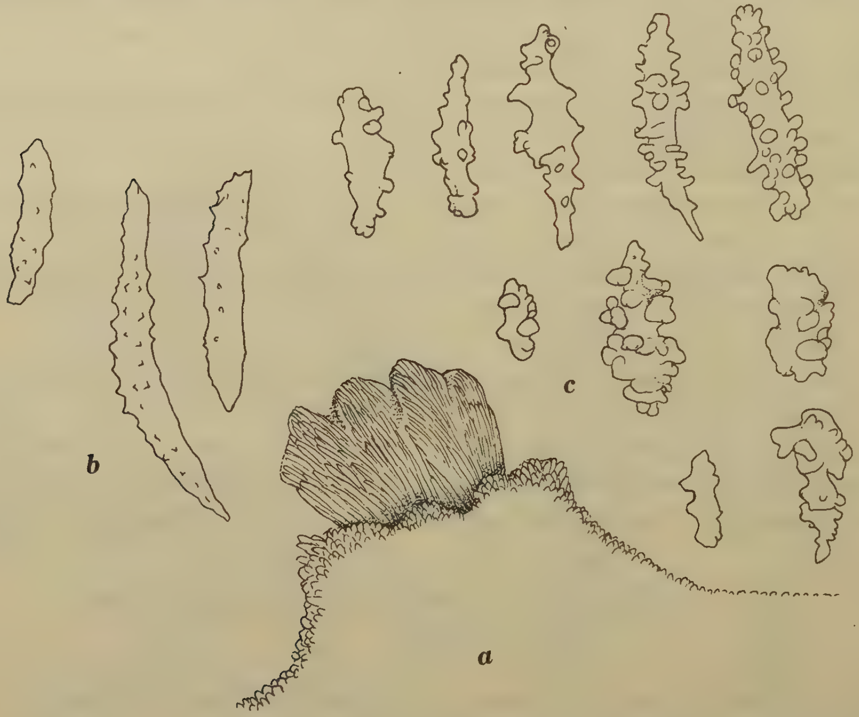

Fig. 7. *Astrogorgia rubra* THOMSON & HENDERSON.
a, Details of polyp extended above calicle; *b*, anthocodial spicules; *c*, coenenchymal spicules.
〔*a*, ×27; b–c, ×140.〕

The polyps are completely retractile and their tip, when the tentacles are wholly withdrawn, is marked by eight rounded points like the verrucae. The anthocodial spicules are closely crowded longitudinally and light red with some grayish yellow thorny spindles, as measuring about 0.2–0.25 mm in length and 0.035 mm in width.

The axis is apparently horny, brown and about 0.5 mm in diameter.

Record of occurrence. Hitherto known only from the Indian Ocean (6° 55′ 6″ N, 72° 55′ E, 210 fms.).

Remraks. The genus *Astrogorgia* was established by VERRILL (1868, p. 413; 1869, p. 43) for a unique species *Muricea sinensis* VERRILL (1865, p. 187, pl. 5, figs. 5–5a) from Hongkong. According to VERRILL's original and emended descriptions, the verrucae of the type species *sinensis* are scattered on all sides and the coenenchyma is granular on surface and deep red in color. In the second species *rubra*, however, the verrucae are said to be disposed in a regularly alternate manner and on larger branches they are almost opposite and the spiral twisting of the axis makes it appear as if the verrucae occurred on all the four sides; the spicules, not figured by them, are said to be all of a pink color, diverse in shape.

In all probability these specimens seem to represent a single species, when any more complete specimens would be found in the future. Furthermore, it is necessary to re-examine the type specimens of both species of *Astrogorgia* to reappraise their position in respect to its affinity with the related genus *Swiftia* DUCHASSAINIG & MICHELOTTI.

13. *Menella indica* GRAY, 1870

(Fig. 8; Pl. VIII, flg. 9)

Menella indica GRAY, 1870a. p. 407; NUTTING, 1912, p. 86; KÜKENTHAL, 1924, p. 184; UTINOMI, 1958, p. 105.

Echinomuricea ? sp. UTINOMI & HARADA, 1958, p. 388 (listed only),

Material. One specimen. 23 km west of Setozaki, 80–150 m. 28–XI–1957. E. HARADA coll.

Description. The specimen is represented by a very long filiform colony, 50 cm in total length, only giving off a shorter simple branch, 11 cm long, at a right angle in the middle. There is no expanded base which occurs in the related species *Menella rubescens* NUTTING.

The stem and branch are very slender, flexible, totally filiform and bluntly pointed at the ends. The diameter of the stem is the widest in the middle where a single branch is given off, namely 1.1 mm, and gradually decreases distally where it is only 0.7 mm. The diameter of the branch is likewise 0.7 mm.

The color of the colony is pale brown. The axis is wolly horny, very flexble, about 0.7 mm in diameter in the middle and almost black.

The polyps are irregularly scattered on all sides, and deeply sunken into their cavities usually opened in the center of low verrucae and usually lengthened along the axis.

Each of the verrucal cavities is about 1 mm in long diameter and about 0.5 mm deep, and they are about 1–2 mm apart.

The coenenchyma, including the verrucal swellings, is evenly spiculose on surface and moderately thick. Their spicules are mostly of the *Echinomuricea*-type, namely thorny scales with a prominent projecing smooth spike and a few thorny basal processes, which are narrower than those of *M. rubescens* NUTTING, as figured by NUTTING (1910a, pl. 22, fig. 13) and BAYER (1959, p. 56, fig. 1A) and those of *Echinomuricea peterseni* HEDLUND, as figured by HEDLUND (1890, pl. 3) and AURIVILLIUS (1931, p. 173, fig. 33). Between these thorny scales, larger thorny

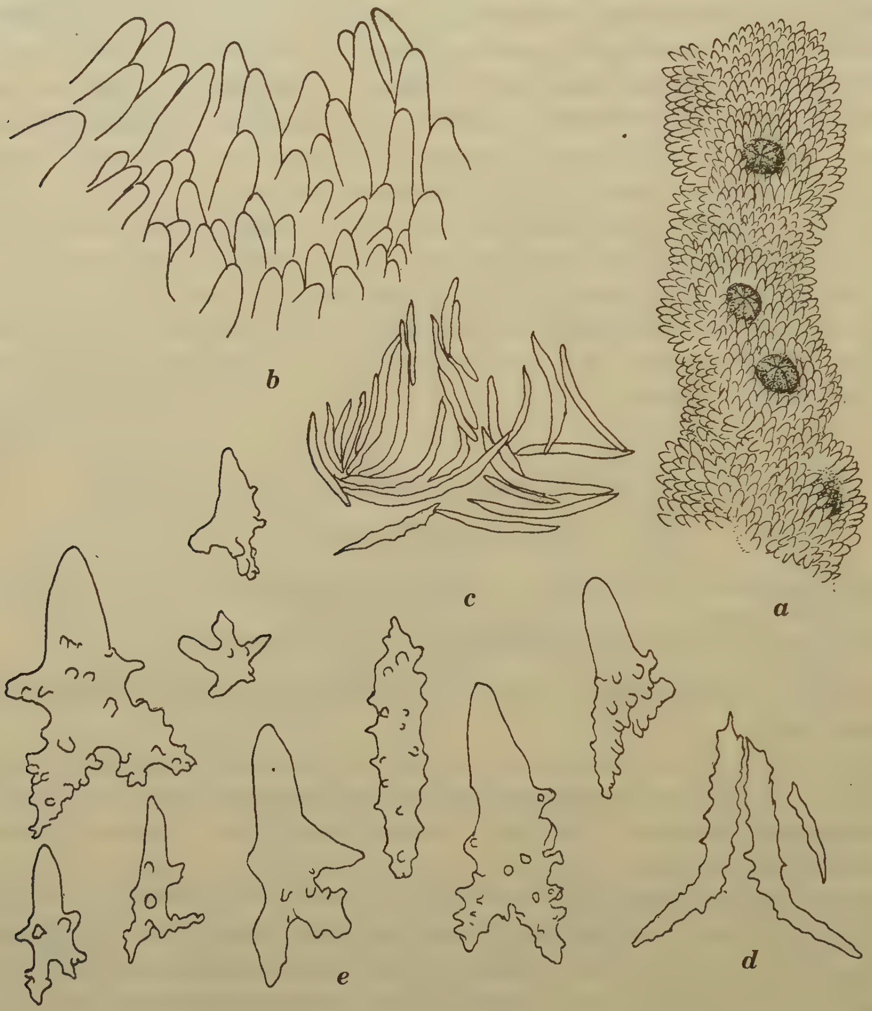

Fig. 8. *Menella indica* GRAY.

a, Part of stem, with 4 polyps sunken into calicular cavities; *b*, details of a part of calicular margins; *c*, arrangement of anthocodial spicules; *d*, a pair of point spicules; *e*, coenenchymal spicules.

〔*a*, ×18; *b*–*c*, ×80; *d*–e, ×150.〕

spindles are sporadically interspersed, filling up the intervening spaces in the deeper layer. However, there is no lobated scales basally.

The polyps are wholly retractile and all sunken deeply below the verrucal margins. The operculum consists of eight converging points and 2–3 collaret rows of slender spicules.

Measurement of these spicules (in mm) are:

Verrucal and coenenchymal thorny scales. 0.16×0.04, 0.18×0.16, 0.2×0.18, 0.21×0.13

Interspersing coenenchymal thorny spindles. 0.23×0.03, 0.3×0.05, 0.33×0.07, 0.33×0.08

Anthocodial, slightly thorny or smooth, slender spindles. 0.11×0.01, 0.13×0.018, 0.16×0.016, 0.19×0.02, 0.2×0.16

Tentacle and pinnule spicules. 0.05–0.08 long

Records of occurrence. Back Bay, Bombay, west coast of India (type locality); 2.6 miles off Osezaki Light, Suruga Bay, Japan, 57 fms. (NUTTING); Tosa Bay, Japan (UTINOMI).

Remarks. In a review of the genus *Placogorgia* STUDER, BAYER (1959a) generically distinguished *Menella* from *Echinomuricea* by the shape of the calicular thorny scales, based on the examination of spicules of two species, *Menella rubescens* NUTTING and *Echinomuricea indomalaccensis* RIDLEY. Among the three species described by NUTTING (1908 and 1910a), *M. grandiflora* from Hawaiian Islands is clearly a member of the stoloniferan genus *Clavularia* (cf. BAYER, 1952, p. 129). On the other hand, *M. rubescens* from Malay Archipelago seemingly approaches to *Echinomuricea* and *M. grayi* from Malay Archipelago approaches to *Muriceides* rather than to *Menella indica* in respect to their spiculation and mode of life (or growth form of the colony).

In comparison with *Echinomuricea*-speces, *Menella indica*, type of the genus, is unbranched or only scantily branched, with thick coenenchyma. Calicles are very low, elliptical in cross section, thickly covered by thorny scales similar to those of the surrounding cortex which are composed of a single broad smooth projecting spike and a few thorny basal branches. Polyps, when retracted, are deeply sunken below calicular margins.

14. *Filigella mitsukurii* KINOSHITA, 1909

(Figs. 9 and 10; Pl. IX, figs. 10–11)

Filigella mitsukurii KINOSHITA, 1909b, p. 1, pl. 1, fig. 1 and pl. 2, figs. 7–9; AURIVILLIUS, 1931, p. 129, textfig. 25, pl. 3, figs. 3–4; BAYER, 1956, p. F206, fig. 148 (3); UTINOMI & HARADA, 1958, p. 388 (listed only).

Elasmogorgia mitsukurii KÜKENTHAL, 1924, p. 149, fig. 104.

? *Elasmogorgia filiformis* NUTTING, 1912, p. 85.

Material. 5 unbranched and scantily branched specimens. Sta. 1, 23 km west of Setozaki, 120 m. Bottom : pure sand. 8–XII–1957. E. HARADA coll.

Description. This is also a very slender filiform gorgonid, not forming any ordinary attachment disk.

The unbranched forms measure 20 cm, 30 cm, 31 cm and 38 cm in length respectively. The bifurcate form is likewise a single whiplike stem, about 17 cm long, with a longer branch, about 22 cm long, arising near its base broken off.

In all these specimens, both the ends are slightly swollen and bluntly pointed like an arrow-head (Fig. 9, *a–d*). In the presumably lower part, the stem measures about 1 mm in diameter, but in the remaining parts it is less than 1 mm in diameter all throughout, mostly 0.5 mm. The color is dirty white.

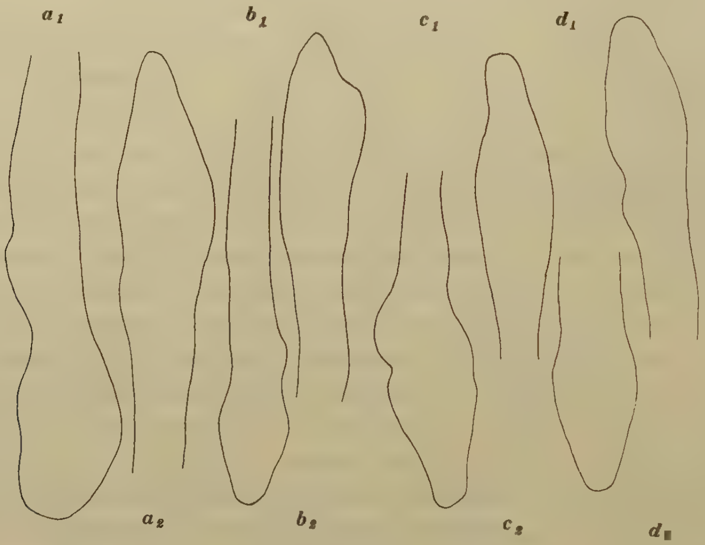

Fig. 9. *Filigella mitsukurii* KINOSHITA.
Outline of both ends of four colonies (*a–d*).
〔×12.〕

The verrucae, which are low cones when viewed from sides, are scattered on all sides, but tend to be lateral and alternate. They are about 0.5–2 mm apart, averaging 1 mm. The axis is very flexible, about 0.25 mm in diameter and yellowish brown.

The coenenchyma is thin and covered with fusiform spicules about 0.2–0.3 mm long. These spicules are generally arranged longitudinally, but around the orifice of the verrucae somewhat radially, not in chevrons.

These coenenchymal spicules are somewhat larger in the surface layer than in the deeper layer, but similarly all short tuberculate spindles bluntly ended, with smooth or slightly roughened warts. They measure in mm as follows:

0.13×0.033, 0.19×0.05, 0.25×0,07, 0.3×0.08, 0.33×0.082

The operculum of the anthocodiae consists of eight points longitudinally disposed and 2 or 3 transverse rows of collarets. These are slightly thorny spindles and measure in mm as follows:

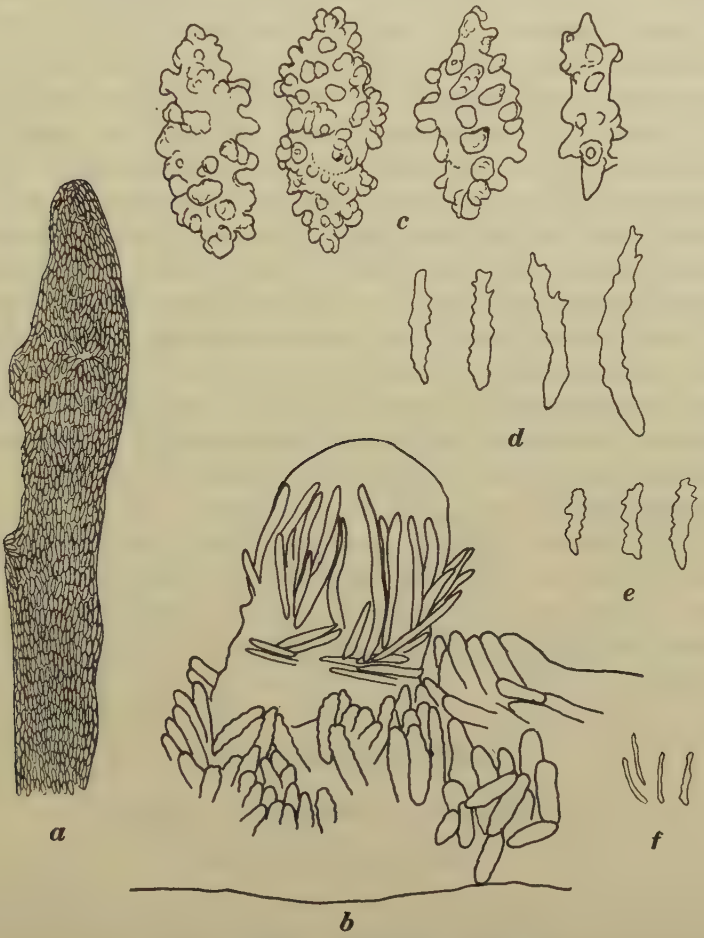

Fig. 10. *Filigella mitsukurii* KINOSHITA.

a, End of colony; *b*, details of polyp partially extended out of calicle; *c*, coenenchymal spicules; *d*, anthocodial spicules; *e*, tentacle spicules; *f*. pinnule spicules.

〔*a*, ×12; b, ×67; *c–f*, ×97.〕

0.16×0.02, 0.19×0.03, 0.21×0.025, 0.25×0.032

Tentacle spicules are all flattened rods, as measuring in mm:

0.082×0.016, 0.114×0.032

Pinnule spicules are slender rodlets, about 0.033–0.082 mm long.

Records of occurrence. South of Jogashima (=Zyôgasima), Sagami Bay, 70 fms. (type locality), Sagami Bay 400–450 m and west of Kyusyu 160–200 m (AURIVILLIUS).

Remarks. As we have seen, most of the genus *Filigella* or *Elasmogorgia* and also *Filigorgia*[1] (STIASNY, (1939, p. 301) are unbranched or scantily branched, filiform gorgonid, usually lacking the ordinary basal disk like the preceding *Menella*. As suggested originally by GRAY (1868, p.. 443) and by KINOSHITA (1909b, p, 1) and later by AURIVILLIUS (1931, pp. 126–143), the genus *Filigella*, with which *Elasmogorgia* are synonymous, may be designated as follows:

Colony filiform, simple or scantily branched, free or fixed according to the bottom nature of its habitat; distal end slightly swollen and bluntly pointed; proximal end rounded and either free or with a small attachment disk; axis horny, very flexible; coenenchyma thin, formed of small colorless warty spindles; calicles only low mounds irregularly or alternately disposed on coenenchyma, their spiculation not specialized.

Recently BAYER (1958, p. 50; 1959 b, p. 17, for *Filigella gracilis*) synonymized the two genera *Filigella* GRAY and *Elasmogorgia* WRIGHT & STUDER with the West Atlantic genus *Thesea* DUCHASSAING & MICHELLOTTI, and transferred to the family Plexauridae from the family Paramuriceidae. So far as I examined on specimens or in the literature, the coenenchyma of *Filigella* seems to be not so thick and two-layered as in most plexaurids, and the anthocodial armature is more powerful so as to form the operculum typical of paramuriceids. So it seems better to retain the genus name under the Paramuriceidae than to unite with the plexaurid *Thesea*.

Family Plexauridae GRAY

15. *Euplexaura attenuata* (NUTTING), 1910

(Fig. 11; Pl. IX, fig. 12)

Plexaura attenuata NUTTING, 1910b, p. 5, pl. 1, figs. 2–2a, pl. 1, figs. 2–2a, pl. 4, fig. 2.
Euplexaura attenuata KÜKENTHAL, 1924, p. 100; STIASNY, 1935, p. 13, textfig. B, pl. 1, fig. 2; UTINOMI & HARADA, 1958, p. 388 (listed only).

Material. 1) One large syecimen, 55 cm long, with 2 branches arising perpendicularly. Tanabe Bay, probably 20–30 m (obtained by a lobster-net). 18–I–

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[1] Very recently I have had an opportunity to examine the type specimens of *Filigorgia saharensis* and *F. ridouroi* from West Africa (STIASNY, 1939) through the courtesies of Drs. VERSEVELDT, VERVOORT and STOCK. On examination I have recognized *Filigorgia* as a valid genus of the Paramuriceidae related to *Filigella*, and the latter species as a synonym of the former type species, *F. saharensss*, having only a slight difference in size of spicules. In both species, the coenenchyma is yellow or dirty white, while the biserially arranged anthocodiae are beautifully purple.

1955. T. YAMAMOTO coll.

2) 4 specimens. Southwest of Minabe, 80–150 m. 28-XI-1957. E. HARADA coll.

3) One specimen, 27 cm long, with a bifurcate branch. Off Nada near Gobô City (obtained by a lobster-net). 28–V–1958. T. YAMAMOTO coll.

Description. The colonies of this plexaurid are all straight, simple or scantily branched. The second materials are all young form, attached to gastropod shells. They vary from 20 cm to 55 cm in height and from 1.2 mm to 2.8 mm in diameter. The largest one of the first material (dried when examind) shows only a narrow dark brown axis, and its diameter is 2.5 mm basally and terminates to 2 mm.

The coenenchyma is dirty white in alcohol, but when living brown. The calicles are evenly distributed on all sides, about 1.5 mm apart. They are hardly raised above the general level of the coenenchyma, and almost all polyps are partially extended.

The calicular orifice distributed on the narrower distal part of the stem is, when viewed from above, somewhat lengthened along the axis, oval in outline, about 1 mm in longest diameter and one-half in shortest diameter. The polyps are completely retractile and deeply sink almost to the horny axis.

The coenenchymal spicules are all colorless, small spindles with multituberculate warts symmetrically arranged usually in 4 girdles. They measure in mm as follows:

0.1×0.017, 0.14×0.017, 0.16×0.07

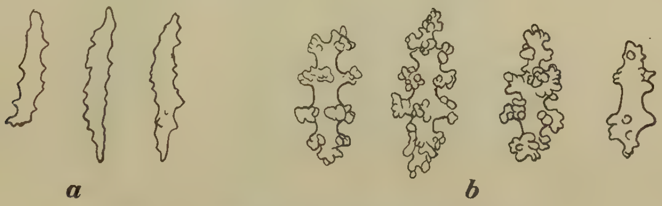

Fig. 11. *Euplexaura attenuata* (NUTTING).
a, Anthocodial spicules; *b*, coenenchymal spicules.
〔*a–b*, ×150.〕

The anthocodial spicules are all colorless, slightly thorny spindles, as measuring in mm:

0.1×0.07, 0.14×0.017, 0.16×0.02

Records of occurrence. Malay Archipelago (NUTTING, STIASNY); Amoy, China (STIASNY). About 20–200 m in depth.

Family Chrysogorgiidae VERRILL

16. *Chrysogorgia rotunda* KINOSHITA, 1913

(Fig. 12)

Chrysogorgia rotunda KINOSHITA, 1913, p. 11, textfigs. 6–8, pl. 2, fig. 2; KÜKENTHAL, 1924, p. 390, fig. 190.

Material. One complete colony. Off Minabe, depth unrecorded. 1938.

Description. The present specimen is larger than the type specimen (11.5 cm long, 7.5 cm wide) described and figured by KINOSHITA (1913). It is attached to a stone by a flat, expanded, white calcareous basal disk, 5 cm across. Its total height is 14.5 cm and the cylindrical polyparium is about 8 cm in spread.

The stem gives off successive spirals of branches at short intervals (about 5 mm below and higher up). For a distance of about 4 cm on the lowest portion, the branches are broken off where the stem is about 3 mm in diameter. In the upper portion, the branches subdivide dichotomously many times, each almost in a horizontal plane, so that the colony forms a cylindrical shape.

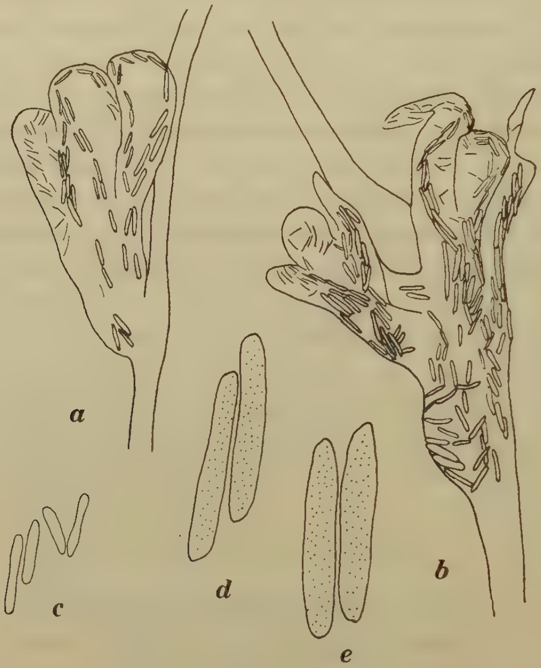

Fig. 12. *Chrysogorgia rotunda* KINOSHITA.
a–b, Polyps; *c*, pinnule spicules; *d*, tentacle spicules; *e*, polyp body spicules.
〔*a–b*, ×33; *c–e*, ×150.〕

The polyps occur on branches at intervals of about 2–3 mm on terminal twigs. They are all small, about 1 mm long and 0.3–0.5 mm wide.

Polypal body spicules are elongate flattened rods with a granular surface, about 0.18–0.5 mm long and 0.02 mm wide. Tentacle spicules are similar in shape, and longitudinally disposed on the dorsal side, about 0.1–0.18 mm long and 0.02–

0.05 mm wide. Pinnnle spicules are tiny rodlets, about 0.035 mm long.

The coenenchyma is very thin, easily rubbed off and devoid of spicules and nematozooids. The axis is straw yellow, showing golden iridescence, while the polyps wholly white.

Record of occurrence. Hitherto known only from the type locality (Sagami Bay, down to 400 fms.)

Family Primnoidae GRAY

17. *Plumarella cristata* KÜKENTHAL & GORZAWSKY, 1908

(Fig. 13; Pl. IX, fig. 13)

Plumarella cristata KÜKENTHAL & GORZAWSKY, 1908, p. 16, textfigs. 14–17, pl. 1, fig. 1; KÜKENTHAL, 1924, p. 258, fig. 147; AURIVILLIUS, 1931, p. 241, textfig. 47 (1).

Plumarella carinata KINOSHITA, 1908a, p. 17, textfig. 3, pl. 1, fig. 8 and pl. 5, fig. 41; KINOSHITA, 1908b, p. 523, textfig. 6, pl. 17, fig. 4; NUTTING, 1912, p. 64.

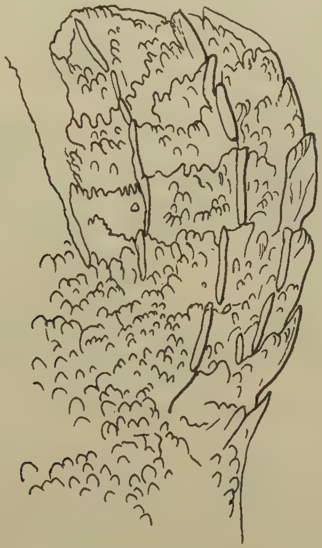

Fig. 13. *Plumarella cristata* KÜKENTHAL & GORZAWSKY.
Polyp in side view.
〔×80.〕

Material. Two specimens, missing the base, 8 cm long and 12 cm long respectively. III–1950. M. OZAKI coll.

Records of occurrence. Sagami Bay, 80–600 m (KÜKENTHAL & GORZAWSKY; AURIVILLIUS); Kôzu Island, south of Izu Peninsula (KINOSHITA); Osezaki, Suruga Bay, 95–106 fms. (NUTTING).

14. *Plumarella serta* KÜKENTHAL & GORZAWSKY, 1908

(Fig. 14; Pl. IX, fig. 14)

Plumarella serta KÜKENTHAL & GORZAWSKY, 1908, p. 14, textfigs. 11–13, pl. 1, fig. 4; KÜKENTHAL, 1924, p. 259.

Material. Three fragments. Off Minabe, 100–200 m. III–1844. S. SAKAGUCHI coll.

Description. Three terminal branches here examined are as usual pinnately branched in one plane, at intervals of about 5 mm. Their stem is about 1.2–1.5 mm in diameter and the side branches are about 0.18 mm in diameter.

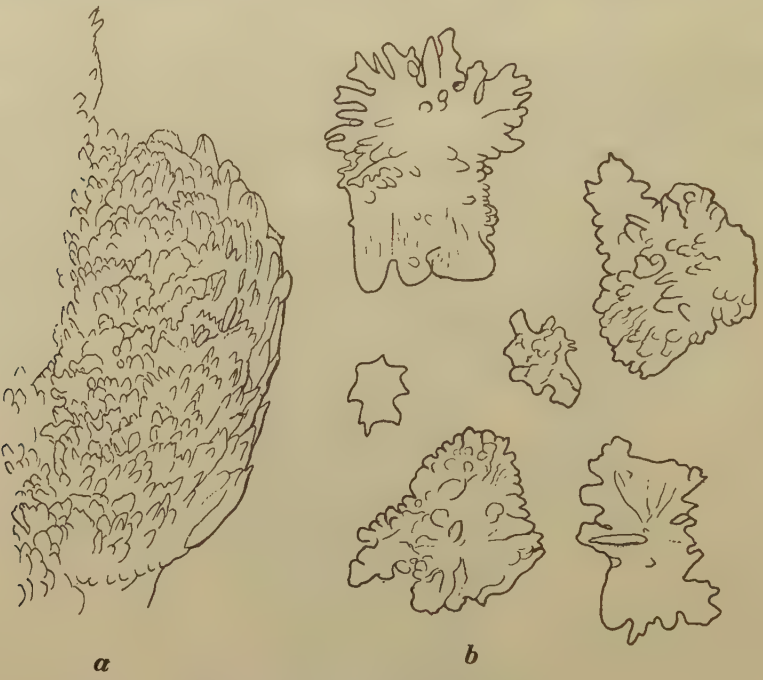

Fig. 14. *Plumarella serta* KÜKENTHAL & GORZAWSKY.
a, Polyp in side view; *b*, thorny scales from polypal body wall.
〔*a*, ×80; *b*, ×150.〕

The polyps are regularly distributed on each side and usually crowded in parts. They are small, stout, club-shaped, usually 0.9–1.5 mm in height and 0.3 mm wide.

Polypal body spicules are closely warted, often nearly smooth, scales with strongly jagged margins. There are often dorsal cristae, which are not so distinct as in the preceding *cristata*. They measure in mm as follows:

0.09×0.018, 0.1×0.07, 0.1×0.018, 0.18×0.12, 0.25×0.18, 0.3×0.2

Record of occurrence. Hitherto known only from the type localty (Sagami Bay, 80–250 m).

19. *Thouarella hilgendorfi* (STUDER), 1878

Plumarella hilgendorfi STUDER, 1878, p. 648, pl. 2, fig. 15.
Thouarella hilgendorfi WRIGHT & STUDER, 1889, p. 62, pl. 21, fig. 4; VERSLUYS, 1906, p. 24, pl. 1, fig. 4 and pl. 2, fig. 7; KINOSHITA, 1908a, p. 21, pl. 5, fig. 42; NUTTING, 1912, p. 66; KÜKENTHAL, 1924, p. 293; AURIVILLIUS, 1931, p. 248, textfig. 48, pl. 5, fig. 8.

Material. Three specimens, 8–11 cm long. Off Minabe, 100–200 m. III–1944. SAKAGUCHI coll.

Records of occurrence. Widely distributed in Malayan waters and Japan such as Jeddobay (=Tokyo Bay) (type locality), Sagami Bay, Suruga Bay and west of Kyusyu, 100–2200 m.

PENNATULACEA

Suborder SESSILIFLORAE

Familly Veretilidae HERKLOTS

20. *Cavernularia obesa* MILNE EDWARDS & HAIME, 1857

For description and synonyms see KÜKENTHAL & BROCH, 1911, p. 181.

Material. One specimen, 15 cm long, contracted. Off Minabe. III–1950.

Records of occurrence. Indian Ocean, Malay Archipelago, Australia and Japan, usually in shallow seas.

Family Echinoptilidae HUBRECHT

21. *Echinoptilum macintoshi* HUBRECHT, 1885

Echinoptilum macintoshi HUBRECHT, 1885, p. 512, 2 pls.; BALSS, 1910, p. 38, pl. 2, figs. 1–3 and pl. 5, figs. 3–5; NUTTING, 1912, p. 48; THOMSON & RENNET, 1927, p. 121, pl. 9, fig. F; UTINOMI & HARADA, 1958, p. 388 (listed only).

Material. 1) 2 specimens. 23 km west of Setozaki, 80–150 m. 28–XI–1957. E. HARADA coll.

2) One specimen. 8 miles southwest of Kirimezaki, 150 m. 16–XII–1957. M. OZAKI coll.

Records of occurrence. Hitherto known commonly from deep water of Japan; for example Kumanonada, 34° 11′ N, 136° E, 130 m (type locality), Sagami Bay, (BALSS; THOMSON & RENNET), Dôgo Island, Zapan Sea (NUTTING), Prov, Rikuzen and Uraga Channel (THOMSON & RENNET). Further recorded irom Hawaiian waters (NUTTING, (1908, p. 561).

Family Kophobelemnidae GRAY

22. *Sclerobelemnon burgeri* (HERKLOTS), 1858

For description and synonyms see BALSS, 1910, p. 27 and HICKSON, 1916, p. 77.

Material. One large specimen, 20 cm long and 1.5 cm wide. Off Tanabe Bay. III–1950.

Record of occurrence. Known from Japan and Indo-Malayan waters, in 150–180 m in depth.

Family Funiculinidae GRAY

23. *Funiculina quadrangularis* (PALLAS), 1766

For description and synonyms see KÖLLIKER, 1870, p. 191 and p. 590, and BALSS, 1910, p. 33.

Material. One specimen, 47 cm long and 2.5 cm wide at base. 23 km west of Setozaki, 80–150 m. 28–XI–1957. E. HARADA coll.

Record of occurrence. Apparently cosmopolitan, 18–2600 m (BALSS).

Family Stachyptilidae KÖLLIKER

24. *Stachyptium dofleini* BALSS, 1909

(Pl. X, figs. 15–16)

Stachyptilum dofleini BALSS, 1909, p. 427.

Stachyptilum superbum BALSS, 1910, p. 36 (not STUDER); KÜKENTHAL & BROCH, 1911, p. 261, figs. 84–91; THOMSON & RENNET, 1927, p. 129, pl. 9, figs. B–C; KUMANO, 1947, p. 1551, fig. 4361.

Stachyptilum dofleini KÜKENTHAL, 1913, p. 262 (emend.).

Material. One specimen. Off Minabe. Depth unrecorded. III–1950.

Description. The specimen is represented by a single large colony, about 19 cm long, of which the polyparinm is about 12 cm long and the sterile stalk is about 7.5 cm, thus the radio of length between the polyparium and stalk is roughly 1.6 : 1. The maximum width of the polyparium is about 4 mm and the diameter of the stalk is about 3 mm in its collapsed condition.

The polyparium is grayish, while the stalk is reddish brown, darker towards the lowest end.

The autozooids are arranged laterally in oblique rows, about 33 in total number, and at the same time 4–6 on one oblique-transverse row, decreasing in number towards up and down. Each of the autozooid calicles in the middle portion is about 4 mm long and 0.7 mm wide, and armed with a number of needles on the outer side; the distal margin is less spinose, usually only one tooth somewhat conspicuous on both sides, though never so spine-like as in the real *St. superbum* as figured by NUTTING (1908, pl. 87, fig. 9) and by KÜKENTHAL (1913, pl. 8, fig. 9). The scale-like siphonozooids occur laterally on the rachis in triangular clusters, leaving a dorso-median streak free.

Records of occurrence. Hitherto known only from Japan, especially Sagami Bay, 90–150 m (BALSS), 80–350 fms. (THOMSON & RENNET), littoral to 150 m. (KÜKENTHAL). According to KUMANO (1947), younger specimens, about 10 cm long, occur abundantly on sandy mud basin in the depths of 3–75 m around the coast of the same bay.

Remarks. As emended by KÜKENTHAL (1913), the relative length of the polyparium and stalk and the less spinose calicular margins may serve to separate the Japanese form from the type species *St. superbum* STUDER (1894) endemic to the Pacific coast of the central and north America.

Suborder SUBSELLIFLORAE

Family Pennatulidae EHRENBERG

25. *Leioptilus fimbriatus* (HERKLOTS), 1858

(Pl. X, figs. 17–18)

Pennatula fimbriata HERKLOTS, 1858, p. 18, pl. 3, fig. 3 and pl. 4, fig. 1.
Leioptilus fimbriata GRAY, 1860, p. 22.
Leioptilus fimbriatus GRAY, 1870b, p. 21.
Pennatula fimbriata KÖLLIKER, 1872, p. 137.
P. sulcata KÖLLIKER, 1880, p. 8, pl. 2, figs. 3–4.
P. fimbriata BALSS, 1910, p. 55, pl. 1, figs. 6 & 11, pl. 4, fig. 3; KÜKENTHAL & BROCH, 1911, p. 376, figs. 171–176; HICKSON, 1916, p. 184, textfig. 36; THOMSON & RENNET, 1927, p. 131; KUMANO, 1947, p. 1548, fig. 4353.
Ptilosarcus brevicaulis NUTTING, 1912, p. 26, pl. 4, figs. 3–3a (after DEICHMANN, 1941).
Leioptilus fimbriatus DEICHMANN, 1941, p. 12 (footnote).

Material. 1) One specimen, Off Minabe. III–1950.

2) Two specimens. 4 miles southwest of Susami, 250–270 m. 19–IV–1957. M. OZAKI coll.

3) One specimen. 8 miles southwest of Kirimezaki, 150 m. 16–XII–1958. M. OZAKI coll.

4) Five small specimens. Stations 1, 2 & 4, 23 km west of Setozaki, 120–150 m. 8–XII–1957. E. HARADA coll.

5) One specimen. 10 miles sothwest of Minabe, 150 m. 10–I–1960. M. OZAKI coll.

Description. This well known pennatulid has often been described in detail by many earlier authors, so that further description of the structure may be unnecessary. But only given here are the measurements of some specimens for comparison.

	Mat. (4)					Mat. (2)		Mat. (5)
Total length (mm)	45	57	60	70	80	64	65	130
Length of rachis (mm)	28	36	37	42	50	40	43	90
Length of stalk (mm)	15	21	23	25	30	23	25	40
Width of rachis (mm)	14	20	17	30	25	17	17	38
Number of leaves	17	15	18	26	20	20	20	29
Length of dorsal margin of leaf (mm)	10	12	8	17	19	10	10	20

Among these specimens, the largest one, 130 mm long, only shows a flat bare median streak on the ventral side of the rachis between the leaves, while in all the other smaller specimens, rangiug from 45 to 80 mm in total length, an open channel-like deep groove is formed continually from up to down on the ventral side, and without exceptions a couple of the anomuran crab *Uroptychus scandens* BENEDICT[1] reside commensally within the groove, as noticed by HICKSON (1916, p. 185).

Records of occurrence[2]. Japan, 190–730 m (BALSS, etc.); Philippines, 18–36 m (KÖLLIKER); Kei Islands, 112–397 m (HICKSON).

Family Pteroeididae KÖLLIKER

26. *Pteroeides breve* KÖLLIKER, 1872

(Pl. X, figs. 19–20)

Pteroeides breve KÖLLIKER, 1872, p. 79, pl. 4, figs. 31–32.

Material. One specimen, Off Minade. Depth unrecorded. III–1950.

Description. This specimen, having a short rachis, about 4 cm long and a plump stalk, about 5.2 cm long and 2 cm wide, may be identified with a little-known species *Pteroeides breve* KÖLLIKER by its shortened tip slightly projecting at the base of terminal leaves. The stem is short but very thick, and the leaves, 18 on each side of the rachis, are directed almost laterally.

A larger leaf is elongate triangular, about 28 mm long and 14 mm wide, with a median siphonozooid plate and 10–12 spicular rays marginally projecting. The colony in alcohol is uniformly flesh-colored.

Record of occurrence. Hitherto known only from the type locality (Bohol Island, Philippines, 6–10 fms,).

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1) BALSS (1913) later recorded this crab from Dr. DOFLEIN's collection but did not mention as to its habitat whatever.

2) *Pennatula fimbriata*, as reported from the coral reef of Koror Island, Palau (UTINOMI, 1956a, p. 240), a photograph of which is further reproduced in my book (UTINOMI, 1956b, pl. 10, fig. 5), is unexpectedly a mistaken identity, although it may also occur there. It should be corrected to *Pteroeides lacazii* var. *spinosum* KÖLLIKER.

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EXPLANATION OF PLATES VII-X

PLATE VII

Fig. 1. *Acalycigorgia inermis* (HEDLUND). ×1
Fig. 2. *Acanthogorgia japonica* KÜKENTHAL & GORZAWSKY. ×1
Fig. 3. *Muricella abnormalis* NUTTING. ×5/3
Fig. 4. *Discogorgia dendritica* (NUTTING). ×4/5

PLATE VIII

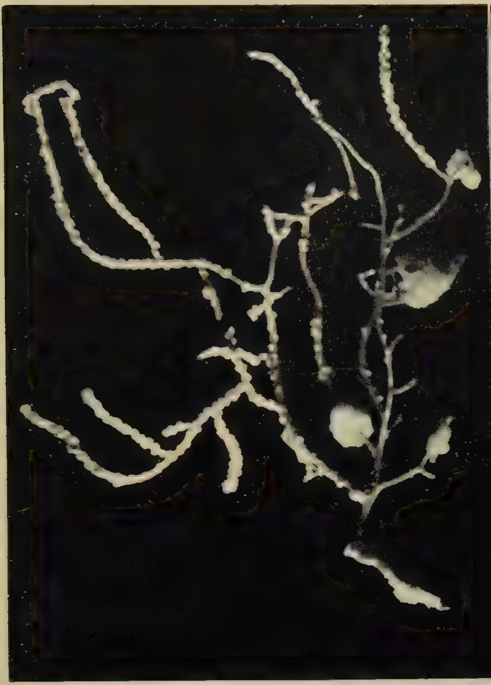
Fig. 5. *Muricella nitida* (VERRILL). ×1
Fig. 6. *Muricella magna* n. sp. (Holotype) ×1
Fig. 7. Distal part of the same, magnified. ×2
Fig. 8. *Astrogorgia rubra* THOMSON & HENDERSON. ×2
Fig. 9. *Menella indica* GRAY. ×1

PLATE IX

Figs. 10–11. *Filigella mitsukurii* KINOSHITA. ×2/5
Fig. 12. *Euplexaura attenuata* (NUTTING). ×1/2
Fig. 13. *Plumarella cristata* KÜKENTHAL & GORZAWSKY. ×1
Fig. 14. *Plumarella serta* KÜKENTHAL & GORZAWSKY. ×1/2

PLATE X

Fig. 15. *Stachyptilum dofleini* BALSS. ×3/5
Fig. 16. Part of rachis of the same, magnified. ×3
Fig. 17. *Leipterus fimbriatus* (HERKLOTS), dorsal side. ×1
Fig. 18. The same with a median groove, ventral side. ×1
Fig. 19. *Pteroeides breve* KÖLLIKER, dorsal side. ×2/3
Fig. 20. The same, ventral side. ×2/3



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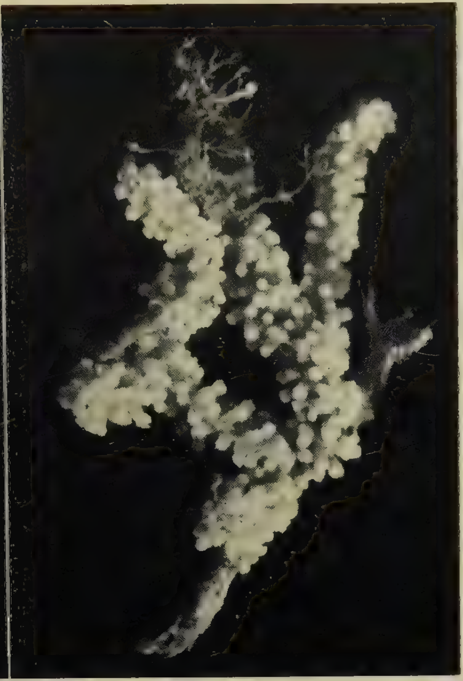

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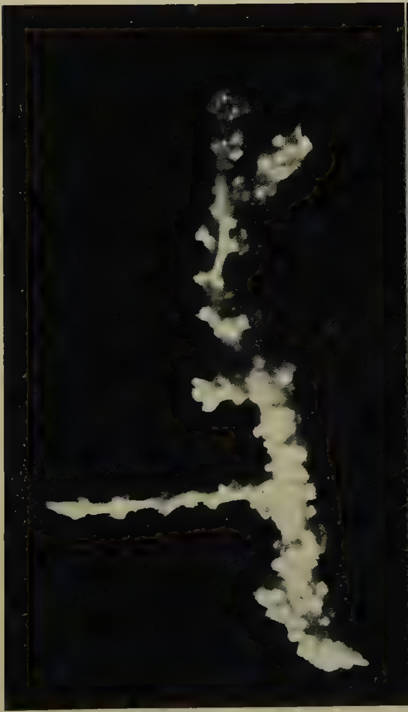

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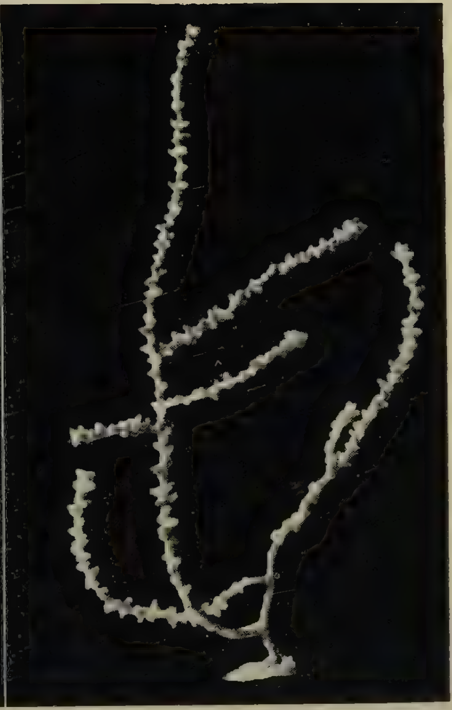

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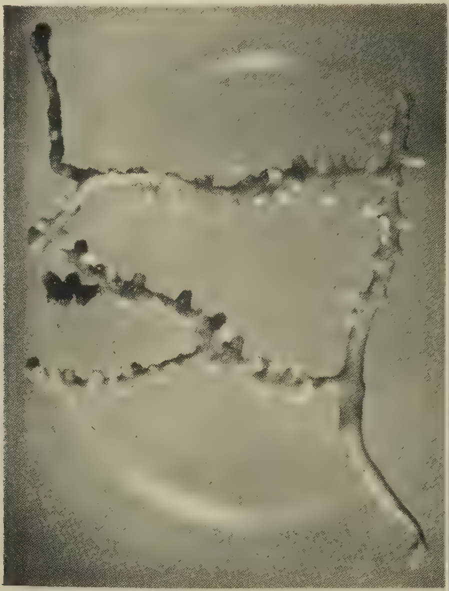
H. Utinomi: Noteworthy Octocorals Collected off Kii Peninsula, 2.



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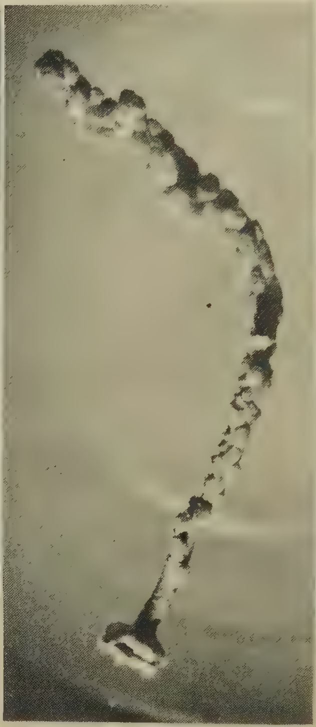

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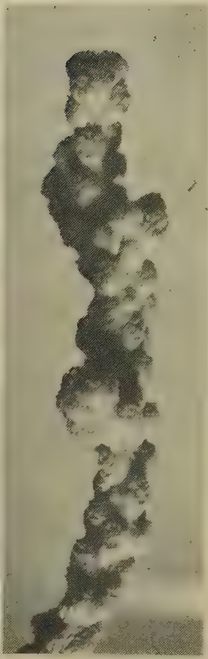

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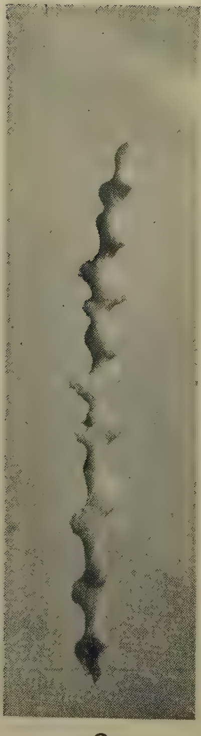

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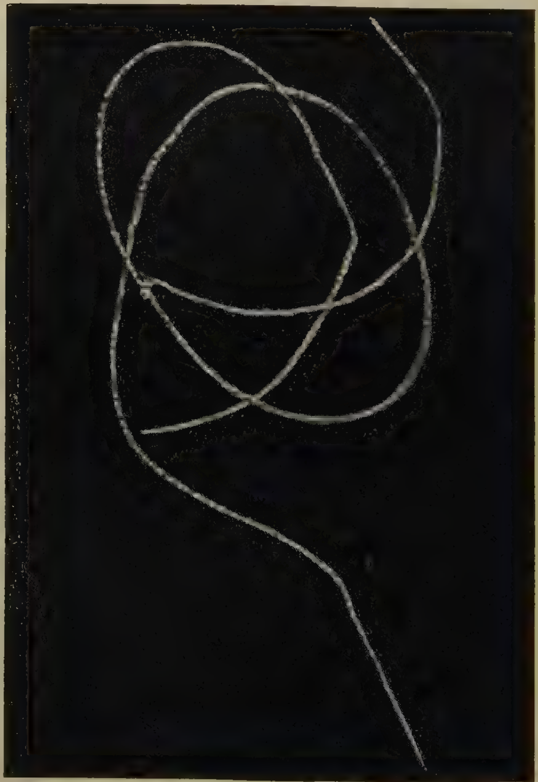

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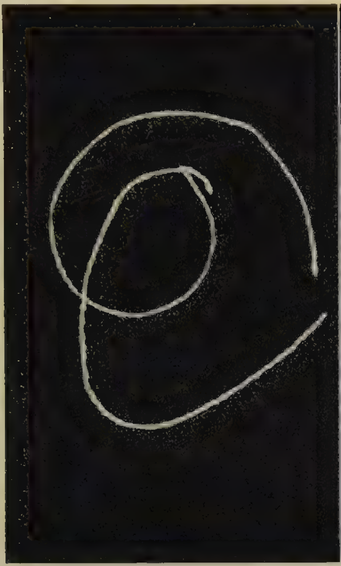
H. UTINOMI: NOTEWORTHY OCTOCORALS COLLECTED OFF KII PENINSULA, 2.



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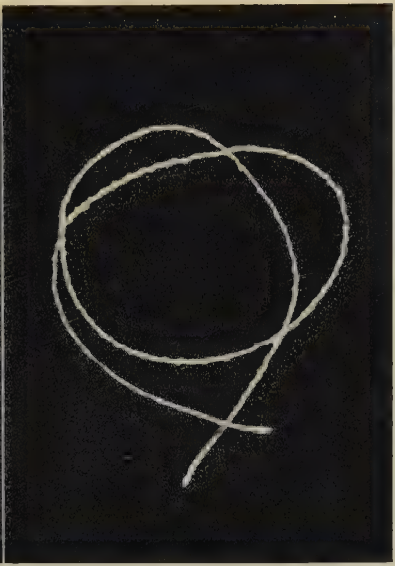

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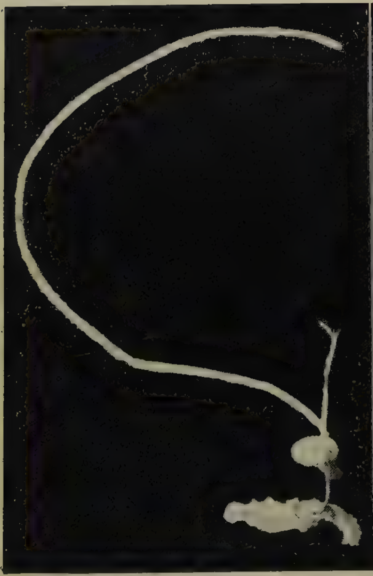

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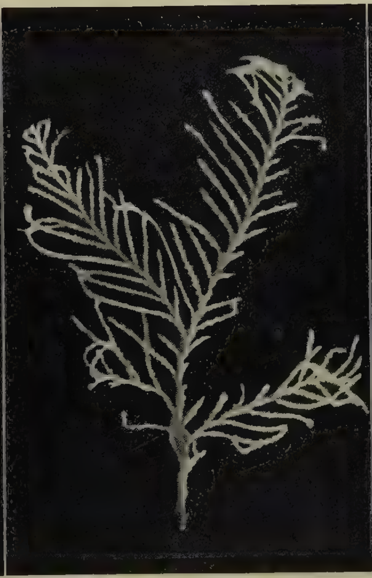

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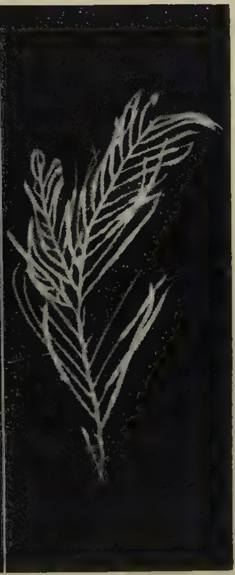

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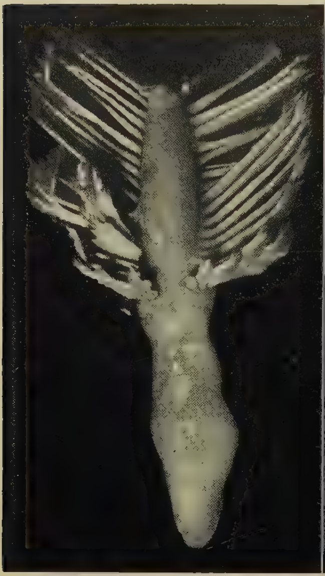

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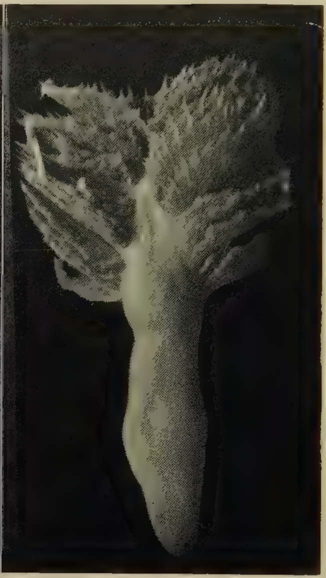

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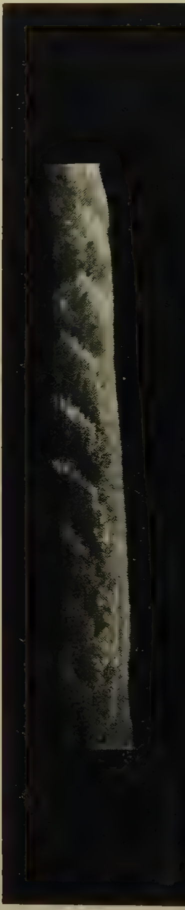

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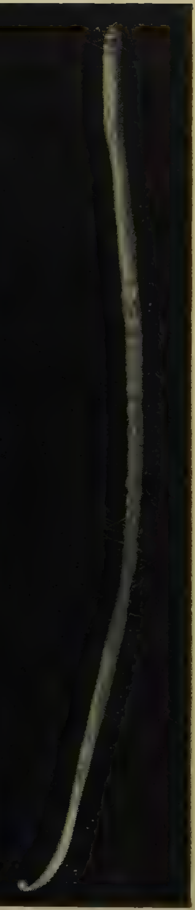

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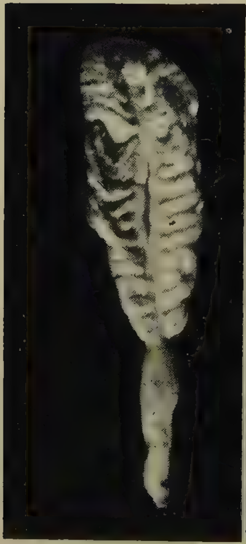

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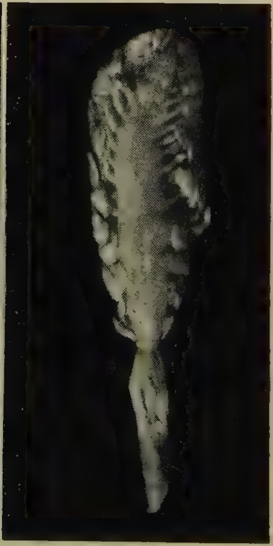

17

H. Utinomi: Noteworthy Octocorals Collected off Kii Peninsula, 2.

A REVISION OF THE NOMENCLATURE OF THE FAMILY NEPHTHEIDAE (OCTOCORALLIA: ALCYONACEA)

II. THE BOREAL GENERA *GERSEMIA, DUVA, DRIFA* AND *PSEUDODRIFA* (n. g.)[1]

Huzio UTINOMI

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With Plate XI and 6 Text-figures

As formerly mentioned (UTINOMI, 1951), the nomenclatorial history of the northern Nephtheidae has been quite confused. The first number of the northern Nephtheidae is RATHKE's *Gorgonia florida* (now known as *Duva florida*) which has been assigned to various genera such as *Nephthya, Eunephthya, Gersemia, Duva, Paraspongodes* and *Capnella.*

In 1869, VERRILL established a new genus *Eunephthya* to accomodate a southern form *Nephthya thyrsoides* VERRILL (1865) taken from the Cape of good Hope, South Africa, together with a northern form *Eunephthya glomerata* (LÜTKEN MS.) taken from Greenland. Apparently, the principal source of confusion between later workers has been the superficial resemblances between the two species living in northern and southern waters, without considering the earliest invalid designation, although VERRILL himself confirmed the former species as the type of *Eunephthya* many years later (VERRILL, 1922, p. 29). Unfortunately, VERRILL's *Eunephthya* is a synonym of *Capnella* which GRAY (1869, Feb.) created for a tropical form *Alcyonium imbricatum* QUOY & GAIMARD only a month before VERRILL's, so that it cannot be used at present (UTINOMI, 1960, p. 28).

In 1878, MARENZELLER established another new genus *Gersemia* for two retractile northern nephtheids. Some years later, the Scandinavian zoologists KOREN & DANIELSSEN (1883) and DANIELSSEN (1887) created a number of nephtheid genera (*Duva, Voeringia, Drifa, Nannodendron, Fulla, Gersemiopsis, Barathrobius, Sarakka, Krystallofanes* and *Organidus*). Most of these genera have been rejected by later systematists. Among them, however, only the genus *Gersemia* of MARENZELLER, as well as *Eunephthya* of VERRILL, has been accepted by KÜKENTHAL (1903–07) and later systematists.

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1) Contributions from the Seto Marine Biological Laboratary, No. 366.

Publ. Seto Mar. Biol. Lab., IX (1), 1961. (Article 12)

A comprehensive revision of the northern Nephtheidae was first undertaken by KÜKENTHAL (1903 07). Unfortunately, he misinterpretted the early type designation of *Eunephthya* of VERRILL and applied the genus name *Eunephthya* to almost all the northern species like *E. glomerata,* with less-spiculated canal-walls. His classification has been generally accepted without question in later years.

MOLANDER and JUNGERSEN, both in 1915, who published the results of their studies on this group, largely agreed with KÜKENTHAL in nomenclature, though did not agree as to the synonyms of some species. VERRILL (1922) first retained two generic names *Duva* and *Drifa* among the genera erected by KOREN and DANIELSSEN.

In the latest revision, however, MADSEN (1944) adopted the generic name *Capnella* instead of *Eunephthya* for the northern Nephtheidae with non-retractile anthocodiae, following the proposal of BROCH (1939).

I am extremely grateful to Dr. Frederick M. BAYER of the United States National Museum for supplying the material studied in conjunction with this note. Thanks are due Dr. Hjalmar BROCH and Dr. F. Jensennius MADSEN for helpful informations on the northern Nephtheidae.

Gersemia fruticosa **(M. SARS)**

(Text-fig. 1; Pl. XI, figs. 1–3)

Material Examined:—A) Three specimens from off Nontucket Shoal, 39°49′00″ N., 68°28′30″ W. ("Albatross" Station 2043), 1467 fms. July 30, 1883.

B) Three specimens from SW of Martha's Vineyard, 39°15′30″ N., 71°25′00″ W. ("Albatross" Station 2562), 1434 fms. August 11, 1885.

Description:—The specimens herein examined consist of a dendritic polyparium, carrying a number of large extended polyps on branches and a cylindrical sterile stalk with a membranous disc encrusting a bulk of blackish gray silt in a mound- or bottle-like appearance. The three specimens of the material A measure in length as follows:

Polyparium	3.6 cm	4.5 cm	6 cm
Stalk	3.5 cm	2.5 cm	3 cm

The color of the colonies yellowish gray.

The polyps, mostly fully expanded, are uniformly large, typically developed, cylindrical in shape, as measuring about 2–5 mm in length and about 1.5 mm in diameter.

The anthocodiae are provided with eight converging double rows of slender spicules. In the anthosteles, nowever, similar slender spicules are transversely arranged. The tentacles, when the polyp is extended, may reach more than 1 mm

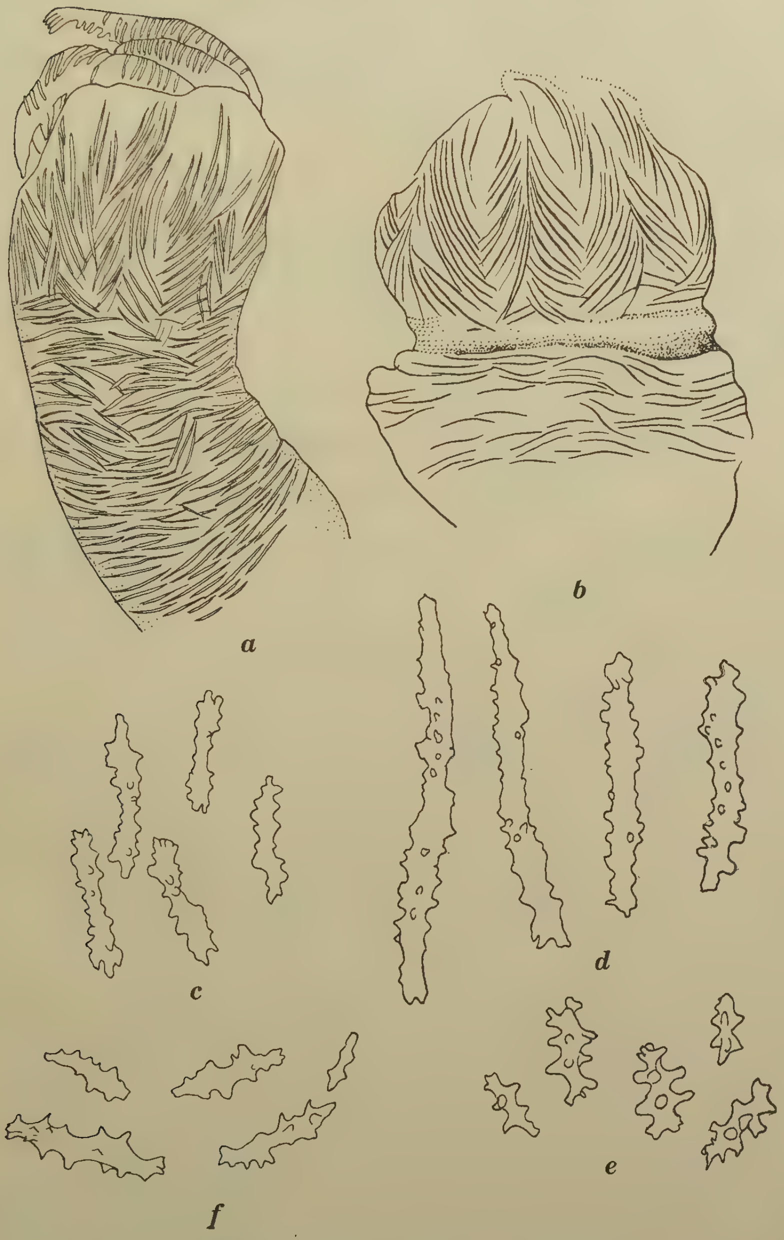

Fig. 1. *Gersemia fruticosa* (M. SARS).

a, Fully extended polyp, showing the arrangement of spicules; *b*, contracted polyp; *c*, tentacle spicules; *d*, anthocodial spicules; *e*, cortical spicules of sterile stalk; *f*, coenenchymal spicules of canal-walls.

〔*a–b*, ×20; *c–f*, ×130〕

long and bear many small spicules arranged transversely on the aboral side. The number of pinnules varies greatly.

On the stem and branches there are many small spinose rods. In the canal-walls, slightly longer rods are very scarcely set.

Measurements of Spicules (in mm):—

Anthocodiae and anthosteles: Slender spindles, scarcely spinose—0.2×0.026; 0.25×0.023; 0.3×0.05; 0.35×0.05

Tentacles: Flattened rods, less spinose—0.12×0.026; 0.17×0.03

Cortex of stem and branches: Spinose rods or rollers—0.09×0.05; 0.12×0.05

Coenenchyma of stem: Spinose rods—0.12×0.05; 0.14×0.035; 0.17×0.05; 0.18×0.05

Type Locality:—Off coast of Norway.

Distribution:—Circumpolar, 0– about 1500 fms.

***Gersemia rubiformis* (EHRENBERG)**

(Text-figs. 2–3; Pl. XI, figs. 4–6)

Material Examined:—A) One specimen from off Cape Cod, Massachusetts, 42°06.5′ N., 70°18′ W., Race Point Light S. 45° E. 4.7 miles ("Speedwell" Station 307), 31 fms. August 25, 1879.

B) Two specimens from Eluitkak Pass, Elson Lagoon, Point Barrow, Alaska (G. E. MACGINITIE collected). August 6, 1948.

Description:—An old specimen of the material A is a whitish colony attached to a broken shell, measuring about 7 cm in length and about 4 cm across. Two fresh specimens of the material B are pink-colored soft colonies having a developed stem with a broad base, 2 cm across and short branches carrying numerous almost retracted polyps placed mostly around the rounded tip of branches. In the latter specimens the polyps are always yellowish, while the cortex of branches and stem are wholly or partly pink in color.

In an extended condition, the branches measure up to 3 cm in height and clavate in shape and terminally thick and bi- or tri-branched. Branches placed more basally are generally shorter and scarcely subdivided. The sterile basal part is generally brownish in color, grooved longitudinally and much corrugated.

The polyps, wholly retractile, are generally smaller than those of the preceding *fruticosa*, about 1.2 mm long and 0.6 mm wide. The tentacles, when extended, are about 0.9 mm long and bear 8–10 pairs of short pinnules.

The spiculation in the polyps and stem is not well developed, comparing with *G. fruticosa*. The spicules in the anthocodiae are few in number, and in some specimens they are only found at the base of the tentacles. The anthostelar part is generally without spicules, although it may happen that in the case of the most powerfully armed anthocodiae, the spicules are found in small numbers only just below the anthocodial part, but they are never disposed so continually down to the base as in *G. fruticosa*.

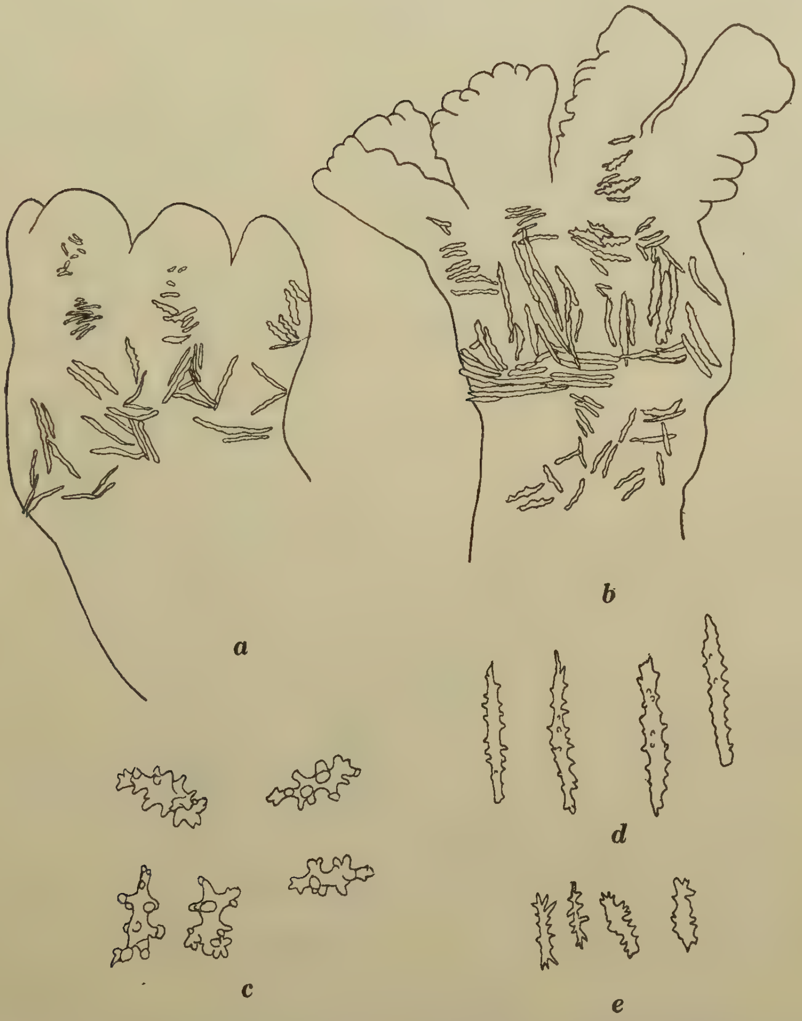

Fig. 2. *Gersemia rubiformis* (EHRENBERG) from off Cape Cod.
a–b, Partly extended polyps, showing the arrangement of spiculus; *c,* cortical spicules of sterile stalk; *d,* anthocodial spicules; *e,* tentacle spicules.
[*a–b,* ×50; *c–e,* ×130]

In the cortex of the branches and stalk there are pink-colored or colorless small spicules in small numbers. In the coenenchyma, however, the spicules are quite absent.

Measurements of Spicules (in mm) :—

Anthocodiae: Slender spindles—0.176×0.017

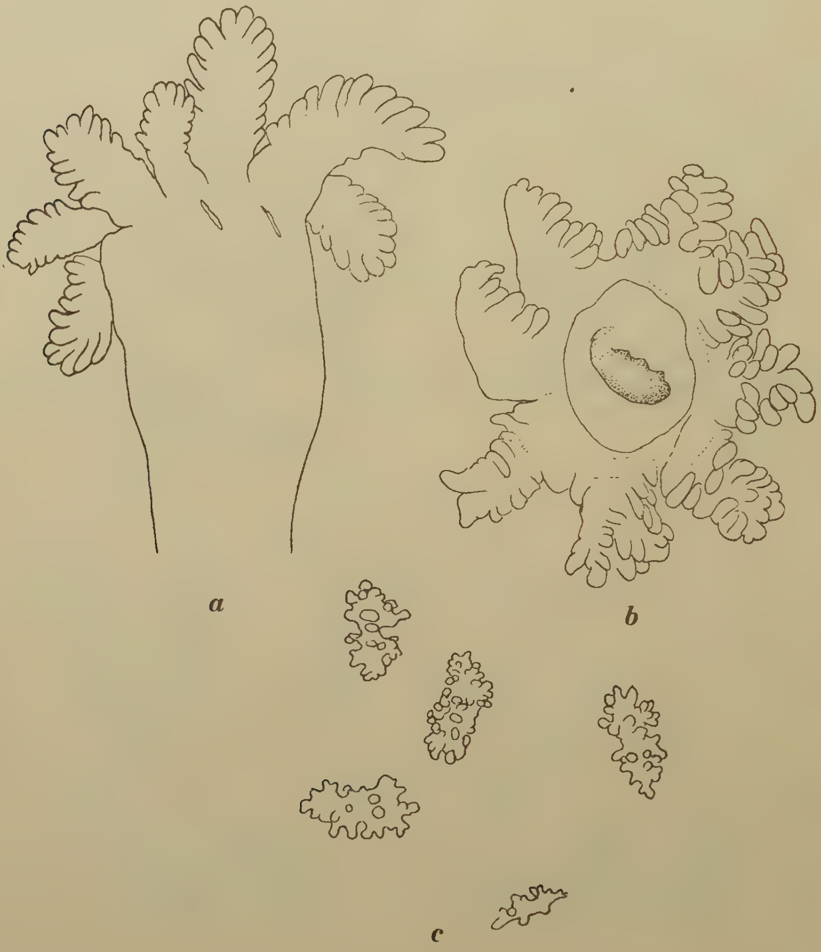

Fig. 3. *Gersemia rubiformis* (EHRENBERG) from Alaska.
a, Fully expanded polyp, side view; *b*, the same, upper view; *c*, cortical spicules of lobes. 〔*a–b*, ×42; *c*, ×130〕

Tentacles: Spinose flattened rods—0.07×0.017; 0.12×0.019

Stalk cortex: Warty rods or rollers, often capstan-like—0.07×0.05; 0.12×0.035

Type locality :—"E mari septentrionalis".

Distribution :—Circumpolar, 0– more than 400 m in depth, usually shallow water between 50–200 m, according to BROCH (1956).

Remarks on the Genus *Gersemia* Marenzeller

The genus *Gersemia* was first created by Marenzeller (1878) for two species *G. loricata* and *G. florida* (=*G. fruticosa*). A number of genera established by Danielssen (1887), such as *Voeringia*, *Fulla*, *Nannodendron*, *Barathrobius*, *Sarakka*, *Krystallophanes* and *Organidus* are probably synonyms of the genus *Gersemia*. Further comment on this genus may be unnecessary here.

Emended Generic Diagnosis:—Nephtheids of dendritic growth. Polyps retractile, crowded on branches or branchlets, armed with eight converging double rows of spindle-like spicules symmetrically arranged in anthocodiae and those transversely arranged in anthosteles. Cortex of stem and branches armed with a few numbers of mostly rods or rollers. Coenenchyma less- or non-spiculated. Mostly living in boreal waters.

Previously Known Species and Their Probable Synonymy :—

1. *Gersemia loricata* Marenzeller (Type of the genus)

Gersemia loricata Marenzeller, 1878, p. 377, pl. 3, fig. 3.

2. *Gersemia fruticosa* (Sars)

Alcyonium fruticosum M. Sars, 1860, p. 140.
Alcyonium fruticosum Koren & Danielssen, 1877, p. 81, pl. 3, figs. 8–11.
Gersemia florida Marenzeller, 1878, p. 375, pl. 3, fig. 2 (not *Gorgonia florida* Rathke, 1806)
Gersemia longiflora Nerrill, 1883, p. 44, pl. 3, figs. 6–6b; Verrill, 1885, pp. 513, 533, pl. 2, fig. 13; Verrill, 1922, p. 48, fig. 13 (type), pl. 14, figs. 3–3a (variety).
Voeringia fruticosa + *V. mirabilis* + *V. abyssicola* + *V. polaris* + *V. pygmaea* + *V. dryopsis* + *Fulla schiertzi* + *Barathrobius digitatus* + *B. palmatus* + *Nidalia arctica* + *Krystallofanes polaris* + *Organidus nordenskjördi* Danielssen, 1887.
Paraspongodes fruticosa May, 1898, p. 388, pl. 23, figs. 1–1c; May, 1900b, pp. 3, 10 & 11.
Eunephthya fruticosa Kükenthal, 1906a, p. 25, pl. 1, fig. 5; etc.
Gersemia fruticosa Molander, 1915, p. 60, pl. 1, fig. 9; etc.
Gersemia fructicosa (sic) Deichmann, 1931, p. 64, pl. 1, fig. 6; pl. 4, figs. 14–20.
Gersemia rubiformis (part) Madsen, 1944, p. 26; Madsen, 1948, p. 4.
Gersemia rubiformis fruticosa Broch, 1956, p. 9.

3. *Gersemia rubiformis* (Ehrenberg)

Lobularia rubiformis Ehrenberg, 1834, p. 282.
?*Halcyonium carneum* Agassiz, 1850, p. 200. (after Verrill)
Alcyonium rubiforme Verrill, 1864, p. 4.
Alcyonium carneum Verrill, 1864, p. 39.
Nannodendron elegans Danielssen, 1887, p. 69, pl. 7, figs. 45–47; pl. 8, figs. 1–76.
Paraspongodes rubra May, 1898, p. 393, fig. 3.
Alcyonium rubiforme + *Paraspongodes rubra* + *P. globosa* May, 1900b, p. 400.
Eunephthya rubiformis Kükenthal, 1906a, p. 21, pl. 1, figs. 1 & 4; Kükenthal, 1907, p. 331.
?*Lithophytum roseum* Nutting, 1912, p. 14, pl. 1, figs. 3–3a; pl. 17, fig. 3 (from Okhotsk Sea).
Alcyonium gracillimum Nutting, 1912, p.21 (from Okhotsk Sea) (not Kükenthal, 1906).
Gersemia rubiformis Molander, 1915, p. 51, pl. 1, fig. 7; Molander, 1918, p. 4.

Gersemia carnea VERRILL, 1922, p. 22, pl. 4, figs. 1–3; pl. 11, fig. 1.
Gersemia rubiformis VERRILL, 1922, pp. 4 & 48, pl. 1, figs. 1–1f; pl. 2, figs. 1–4a; pl. 17A, fig. 1.
Eunephthya rubiformis DEICHMANN, 1936, p. 63, pl. 4, figs. 21–25.
Gersemia rubiformis BROCH, 1935, p. 17.
Gersemia rubiformis (part) MADSEN, 1944, p. 26; MADSEN, 1948,
Gersemia rubiformis rubiformis BROCH, 1956, p. 7.

4. *Cersemia clavata* (DANIELSSEN)
Voeringia clavata DANIELSSEN, 1887, p. 29.
Voeringia capitata DANIELSSEN, 1887, p. 32.
Paraspongodes glacialis MAY, 1898, p. 390.
Paraspongodes griegi MAY, 1900b, p. 395.

5. *Gersemia crassa* (DANIELSSEN)
Sarakka crassa DANIELSSEN, 1887, p. 113 (Type of *Sarakka*).

6. *Gersemia danielsseni* (STUDER)
Voeringia danielsseni STUDER, 1891, p. 552.
Paraspongodes danielsseni STUDER, 1901, p. 31.

7. *Gersemia uvaeformis* (MAY)
Paraspongodes uvaeformis MAY, 1900b, p. 395.

8. *Gersemia marenzelleri* KÜKENTHAL
Gersemia marenzelleri KÜKENTHAL, 1906c, p. 64, pl. 3, fig. 15, textfigs. 45–46.

Duva florida (RATHKE)

(Text-fig. 4; PI. XI, fig. 7)

Material Examined:—One specimen from off Grand Banks, 42°55′30″ N., 50°51′00″ W. ("Albatross" Station 2429), 471 fms. June 23, 1885.

Description:—The specimen is 12 cm in length of which 3.5 cm belongs to the sterile stalk. The color of the colony is dark brown, probably because of old material.

The sterile stalk is very thick and expanded towards the base, where it is about 4 cm across. Its surface is apparently quite smooth.

The branches are numerous and show great ramification. These are quite umbellate, bearing cushon-like clusters of small polyps at their tips. Each polyp is cylindrical in shape, about 2 mm long and 0.6-0.7 mm wide and not retractile.

The armature is weak, the spicules are arranged in eight double rows from the base of the tentacles down to the bottom of the polyps, not differentiated between the head and stalk. The tentacles are long, with up to 15 pairs of filiform pinnules and devoid of spicules.

The cortex of the branches is apparently naked, while the cortex of the stalk contains small spicules, though their density is much variable in places. The canal-walls are without spicules.

Measurements of Spicules (in mm) :—

Polyps: Flattened spinous rods bluntly ended—0.16×0.05; 0.18×0.056; 0.2×0.05; 0.23×0.05; 0.3×0.05

Stalk cortex: Tiny tuberculate rods or rollers, rarely crosses—0.11×0.028; 0.11×0.056; 0.12×0.056

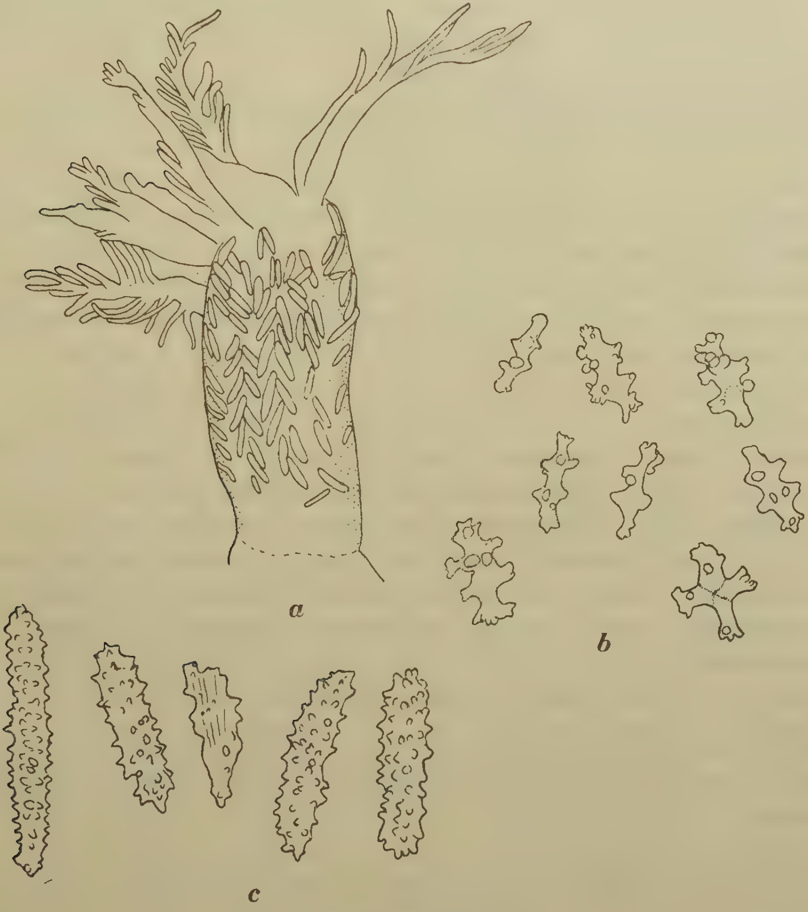

Fig. 4. *Duva florida* (Rathke).
a, Fully extended polyp; *b*, cortical spicules of sterile stalk; *c*, anthocodial spicules. 〔*a*, ×27; *b–c*, ×130〕

Type Locality :—Off the west coast of Norway.

Distribution :—Circumpolar; according to Deichmann, this (if synonymous with *Duva multiflora*) is usually at depths of 110–300 fms. off the coast of New England, North America, while according to Madsen in the Norwegian seas mainly found at depths greater than about 200 m.

Remarks on the Genus *Duva* KOREN & DANIELSSEN

The genus *Duva*, created by KOREN and DANIELSSEN (1883) for a single species *Duva rosea* from Norwegian seas, was lumped by KÜKENTHAL (1896, p. 131) into his instituted elastic genus *Paraspongodes* together with DANIELSSEN's *Voeringia*, *Fulla*, *Barathrobius*, *Gersemiopsis*, *Drifa* and MARENZELLER's *Gersemia*, and MAY (1898, 1900 a, b) followed his procedure. KÜKENTHAL (1903-07) later abandoned this *Paraspongodes* and erroneously adopted VERRILL's *Eunephthya* except for *Gersemia* for all the northern Nephtheidae.

Lately VERRILL (1922, p. 34) revived the earliest available name *Duva* for only the type species *Duva rosea* KOREN and DANIELSSEN and synonymized it with his earlier described *Alcyonium multiflorum*. This *Duva* undoubtedly corresponds with KÜKENTHAL's group "Eunephthya Umbellatae", though not adopted by either MOLANDER or MADSEN, and seems to be generically valid, showing in many respects an intermediate condition between *Gersemia* and *Drifa*. From the former genus it differs in having weakly developed coenenchyma and non-retractile polyps with simple weak armature. From *Drifa* it differs especially in having cylindrical polyps somewhat contractile. Regarding the synonyms here suggested I am not confident at present.

Emended Generic Diagnosis :—Nephtheids of upright growth, umbellate or subumbellate. Polyps somewhat contractile, but not retractile, cylindrical in shape, rather weakly armed with eight coverging double rows of rods symmetrically disposed continually from anthocodiae to anthostele, blending downwards. Spicules of polyps mostly tuberculate or spinose rods. Cortex of stem naked or weakly armed with small rods, rollers, spindles or capstans, variable between species.

Previously Known Species and Their Probable Synonymy :—

The synonyms given here are only provisional and their decision will be possible by re-examining the type specimens or more corresponding specimens, if available.

1. *Duva florida* (RATHKE)

Gorgonia florida RATHKE, 1806, in: O. F. MÜLLER's "Zoologica Danica", p. 20, pl. 137. (Not seen.)
Duva florida KOREN & DANIELSSEN, 1883, p. 5, pl. 2, figs. 13-21.
Eunephthya rosea var. *umbellata* KÜKENTHAL, 1906a, p. 26, text-fig. F, pl. 1, figs. 3 & 6.
Eunephthya rosea var. *umbellata*+*E. florida* KÜKENTHAL, 1907, pp. 364, 374.
Eunephthya rosea var. *umbellata*+*E. florida* MOLANDER, 1915, p. 82, pl. 2, figs. 16 & 23.
Eunephthya rosea var. *umbellata* THOMSON, 1927, p. 15.
Eunephthya florida DEICHMANN, 1936, p. 62.
Capnella florida MADSEN, 1944, p. 30, fig. 21; MADSEN, 1948, p. 12.

2. ?*Duva multiflora* (VERRILL)

Alcyonium multiflorum VERRILL, 1879, p. 200.

Duva rosea KOREN & DANIELSSEN, 1883, p. 1, pl. 1, figs. 1–10; pl. 2, figs. 1–12 (Type of the genus).

?*Duva pellucida* + *D. pulchra* KOREN & DANIELSSEN, 1887, pp. 3–5, pl. 3, figs. 1–24.

?*Duva arborescens* + *D. aurantiaca* + *D. frigida* + *D. glacialis* + *D. spitzbergensis* + *D. violacea* + *D. flava* + *D. cinerea* DANIELSSEN, 1887, pp. 37, 41, 43, 46, 49, 52, 54, 56.

?*Eunephthya rosea* + *E. spitzbergensis* MOLANDER, 1915, pp. 79, 83.

Duva multiflora VERRILL, 1922, p. 35, text-fig. 6 (type), pl. 4, fig. 7; pl. 15, fig. 7.

3. *Duva bicolor* (UTINOMI)

Eunephthya bicolor UTINOMI, 1951, p. 35, text-fig. 5, pl. 1.

Drifa glomerata **(VERRILL)**

(Text-fig. 5; Pl. XI, fig. 8)

Material Examined:—One small specimen from about 9 miles off Nova Scotia, Chebucto Head Light ("Speedwell" Station 118), 53 fms. September 24, 1877.

Description:—The specimen herein examined is a small colony, measuring the polyparium 22 mm in length, 17 mm in width and the stalk 5 mm in length and 6 mm in diameter. According to VERRILL, however, it sometimes becomes larger, up to 5 inches high.

The colony is brownish in color. The trunk is stout, apparently naked at the base and the polyparium consists of multiramified branchlets covered with close clusters of 3 to 6 roundish, clavate polyps.

The individual polyps are non-retractile, generally bent inward and clavate in form, measuring about 1.5–2.1 mm long and 0.85–0.95 mm wide.

The polyp armature consists of a coat closely packed with spinous clubs longitudinally at the distal part which pass downwards into spindles transversly bending from the dorsal side. These anthocodial spicules are generally asymmetrically developed, becoming larger toward the dorsal side.

In the cortex of the stem and branches, small tuberculate spindles are closely distributed. In the canal-walls, similar spicules are sparsely set.

Measurements of Spicules (in mm):—

Distal end of anthocodiae: Spinous clubs—0.23×0.07; 0.25×0.09; 0.28×0.1

Lower part of anthocodiae: Spinous spindles, narrower at lower end—0.16×0.05; 0.2×0.05; 0.25×0.07

Anthosteles: Spinous spindles—0.16×0.05; 0.25×0.07; 0.3×0.06; 0.3×0.08

Tentacles: Curved flattened rods—0.07×0.009; 0.09×0.018

Cortex of stem and branches: Tuberculate rods or rollers—0.09×0.05; 0.12×0.07; 0.14×0.09

Canal-walls of stem: Tuberculate rods or rollers—0.1×0.05; 0.14×0.09

Type Locality:—Greenland.

Distribution:—Circumpolar, but hitherto not recorded from the Subarctic region of the North Pacific.

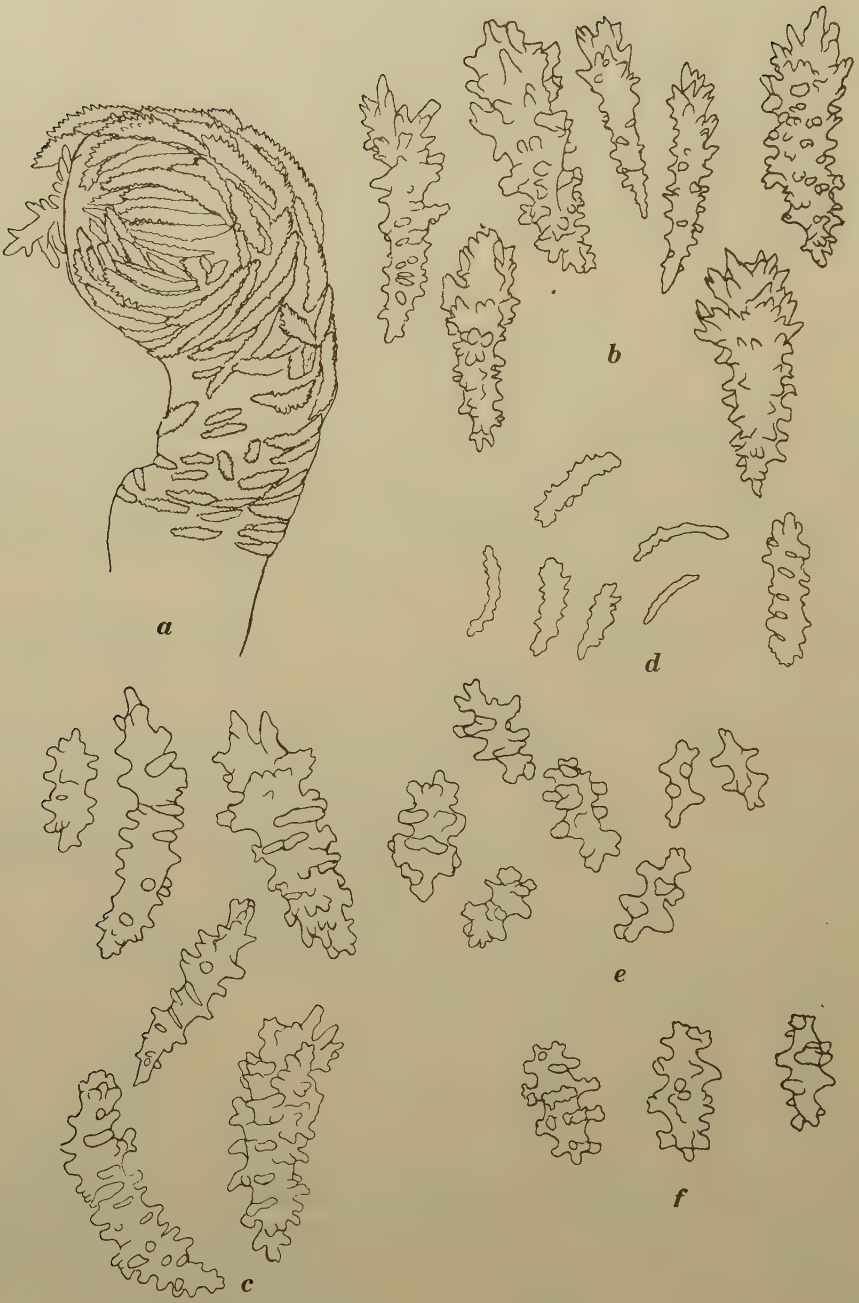

Fig. 5. *Drifa glomerata* (VERRILL).

a, Polyp, side view; *b*, anthocodial spicules; *c*, anthostelar spicules; *d*. tentacle spicules; *e*, cortical spicules of sterlle stalk; *f*, coenenchymal spicules of sterile stalk. 〔*a*, ×33; *b*–*f*, ×130〕

Remarks on the Genus *Drifa* DANIELSSEN

As commented by VERRILL (1922, pp. 30–33), he at first treated the northern species *D. glomerata* from Greenland under the same genus as *Eunephthya thyrsoides* VERRILL from South Africa. Later on he separated himself it from the genus *Eunephthya* (properly *Capnella*) and assigned to *Drifa*, a genus created by DANIELSSEN (1887) for two northern nephtheids (*D. hyalina* and *D. islandica*), and synonymized its type species *D. hyalina* with his *Eunephthya glomerata*.

In general appearance, the genus *Capnella* (=*Eunephthya*) in tropical or warm temperate seas seems to be closely related to the northern forms now referable to the genus *Drifa*, but it can be differentiated from the latter in having much spiculated coenenchyma and asymmetrically developed foliate spicules (cf. BROCH, 1939, p. 14; UTINOMI, 1960, p. 30). Another genus *Gersemiopsis* of DANIELSSEN (type *G. arctica*) may be a synonym of *Drifa*.

Emended Generic Diagnosis:—Nephtheids of dendritic growth form. Stem thick, erect, leathery. Branches closely beset with non-retractile polyps everywhere. Polyps clavate, incurved and armed with clubs longitudinally, though not converging in eight double rows in anthocodiae and passing obliquely or transversely in anthosteles. Canal-walls with few number of spicules. Occurring mostly in the Arctic and North Atlantic seas.

Previously Known Species and Their Probable Synonymy:—

1. *Drifa glomerata* (VERRILL)

Nephthya glomerata VERRILL, 1869a, p. 284; VERRILL, 1869b, p. 97.
Ammothea luetkeni MARENZELLER, 1878, p. 372, pl. 3, fig. 1.
Alcyonium lütkeni VERRILL, 1879, p. 200.
Drifa hyalina DANIELSSEN, 1887, p. 59, pl. 7, figs. 1–44 (Type of the genus).
Drifa islandica + *Nephthya flavescens* + *Nephthya rosea* + *N. polaris* + *Gersemiopsis arctica* DANIELSSEN, 1887, pp. 65, 81, 87, 92, 99.
Eunephthya glomerata KÜKENTHAL, 1906b, p. 78; etc.
Paraspongodes luetkeni + *P. sarsi* MAY, 1900b, p. 399.
Eunephthya glomerata + *E. flavescens* MOLANDER, 1915, pp. 72, 74, pl. 2, figs. 17 & 19.
Drifa glomerata VERRILL, 1922, pp. 31, 46, pl. 5, figs. 2–2a; pl. 14, figs. 2–2b; pl. 15, figs. 1–5; pl. 17A, figs. 2–3.
Eunephthya glomerata DEICHMANN, 1936, p. 61.
Capnella glomerata MADSEN, 1944, pp. 29–30, fig. 22; MADSEN, 1948, pp. 9–12; BROCH, 1956, p. 4 (distribution map).

2. ?*Drifa antarctica* (KÜKENTHAL)

Paraspongodes antarctica KÜKENTHAL, 1902, p. 300.
Eunephthya antarctica KÜKENTHAL, 1906b, p. 75, pl. 3, figs. 14–15; pl. 12, figs. 69–78.

Pseudodrifa nigra (POURTALÈS)

(Text-fig. 6; Pl. XI, figs. 9–10)

Material Examined:—Three specimens from off Georgia, 30°44′00″ N., 79°26′00″ W. ("Albatross" Station 2415), 440 fms. April 1, 1885.

Description :—Each of the above three specimens consist of two main stems arising from a broad basal expansion which clings a bit of dead coral block. The color of the colonies is sepia-brown with paler whitish ridges on the polyps. The stalk and basal membrane are only brownish. They measure as follows:

Length	17 mm	25 mm	30 mm
Width	17	25	35
Length of stalk	8	10	10

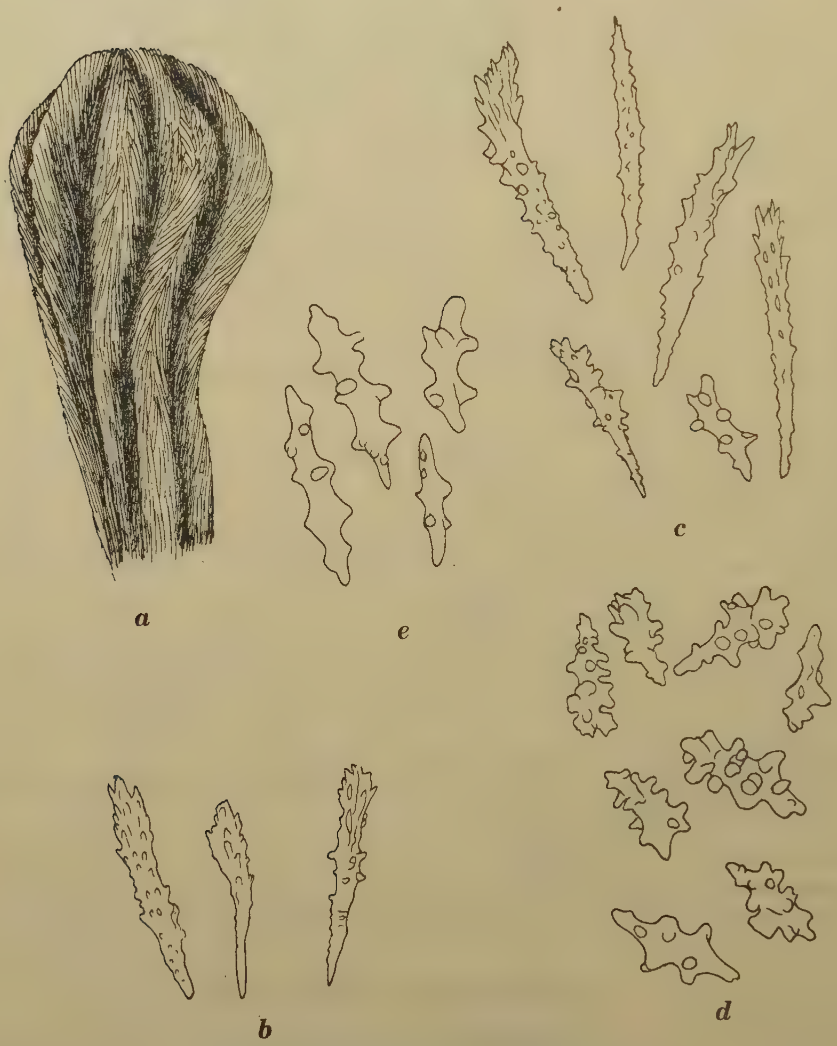

Fig. 6. *Pseudodrifa nigra* (POURTALÈS).
a, Polyp, side view; *b*, tentacle spicules; *c*, polypal spicules; *d*, cortical spicules; *e*, coenenchymal spicules. [*a*, ×20; *b-d*, ×130]

The broad, short stem radially gives off several short branches which carry a number of large polyps at their ends.

The polyps are about 3 mm long, 1.5 mm wide distally and apparently pear-shaped. They are not retractile and bear long stalk, exceeding the terminal head.

The polyps are always provided with eight sharply defined longitudinal ridges continually from the tip to the base, which are filled with innumerable spicules placed in chevrons. These eight ridges continue over the back of the tentacles where similar spinous spicules are disposed longitudinally. These spicules are mostly slender thorny clubs sharply pointed at their lower ends. Spicules between the ridges, not attaining the peak of ridges, are generally slender spindles pointed at both ends.

The cortex of the stem contains small tuberculate rollers or clubs with rounded warts. In the coenenchyma there are rods with a few rounded warts which may be derived from the outer rollers. These coenenchymal spicules are rather numerous in comparison with *Drifa glomerata,* though never abundant.

Measurements of Spicules (in mm) :—

Polyps: Slender spinous clubs or spindles—0.26×0.05; 0.28×0.035; 0.3×0.035; 0.33×0.035

Tentacles: Slender spinous clubs—0.14×0.035; 0.22×0.035; 0.25×0.035

Cortex of stem: Tuberculate rollers or clubs—0.1×0.035; 0.12×0.04; 0.14×0.05

Coenenchyma of stem: Weakly tuberculated rods—0.12×0.035; 0.15×0.05; 0.21×0.05; 0.23×0.04

Type Locality:—Off Sand Key, Florida, 120 fms. (POURTALÈS Gulfstream Explor.).

Remarks on the Genus *Pseudodrifa* (n. g.)

The species *nigra* herein described was originally assigned to *Nephthya* by POURTALÈS (1868, p. 130), but later has been treated as a member of the genus *Eunephthya.* Apparently the polypal spicules resemble somwhat those of *Drifa glomerata,* but the mode of their arrangement in the polyps and tentacles is quite unique. Likewise, the growth form of the colonies and the shape of the polyps are greatly different. The coenenchyma is moderately spiculated, as noticed by MOLANDER and STUDER for the other related species (*racemosa* and *groenlandica*). Furthermore, the native places of the species *nigra* is the Atlantic coast of North America from Florida to Georgia where lies in the subtropical area, apart from the native places of *Drifa glomerata* and its related species.

Therefore I dare create a new genus *Pseudodrifa* for these Northwestern Atlantic species, designating the so-called *Eunephthya nigra* (POURTALÈS) as the type species.

New Generic Diagnosis :—Nephtheids of low shrubby growth form with short sterile stalk and poypiferous short twigs. Polyps non-retractile, large, clavate in form and with well defined eight longitudinal ridges closely packed with club-like slender spicules continually. Spicules not scarce in coenenchyma. Occurring in the Northwestern Atlantic, from Florida to Greenland.

Previously Known Species and Their Probable Synonymy:—

1. *Pseudodrifa nigra* (POURTALÈS) (Type of the genus)
   Nephthya nigra POURTALÈS, 1868, p. 130.
   Eunephthya nigra VERRILL, 1883, p. 44.
   Paraspongodes nigra MAY, 1900a, p. 148.
   Eunephthya nigra KÜKENTHAL, 1906b, p. 77; KÜKENTHAL, 1907, p. 350; DEICHMANN, 1936, p. 60, pl. 1, fig. 7; pl. 4, figs. 5–13; pl. 27, figs. 1–2.
2. *Pseudodrifa racemosa* (STUDER)
   Eunephthya racemosa STUDER, 1891, p. 551; STUDER, 1901, p. 33, pl. 4, figs. 1–2.
   Paraspongodes racemosa MAY, 1900a, p. 148.
   Eunephthya racemosa KÜKENTHAL, 1906b, p. 79; KÜKENTHAL, 1907, p. 359.
   Drifa racemosa VERRILL, 1922, p. 34, pl. 14, fig. 4 (fig. 3 mentioned in text is an error).
3. *Pseudodrifa groenlandica* (MOLANDER)
   Eunephthya groenlandica MOLANDER, 1915, p. 78, text-fig. 13C, pl. 2, fig. 18.
   Capnella glomerata f. *groenlandica* MADSEN, 1944, p. 30, figs. 22r–x.

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EXPLANATION OF PLATE XI

Figs. 1–3. *Gersemia fruticosa* (M. SARS) from off Nontucket Shoal ("Albatross" Station 2043), 1467 fms. Slightly less than natural size.

Fig. 4. *Gersemia rubiformis* (EHRENBERG) from off Cape Cod, Massachusetts, ("Speedwell" Station 307), 31 fms. Slightly less than natural size.

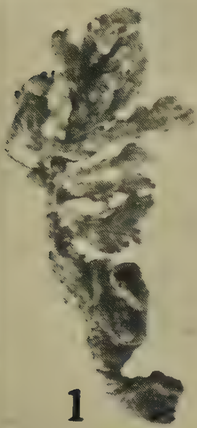
Figs. 5–6. *Gersemia rubiformis* (EHRENBERG) from Elaitkak Pass, Elson Lagoon, Point Barrow, Alaska (G. E. MACGINITIE coll.). Approximately ×4/5.

Fig. 7. *Duva florida* (RATHKE) from off Grand Banks ("Albatross" Station 2429), 471 fms. Approximately ×2/3.

Fig. 8. *Drifa glomerata* (VERRILL) from off Nova Scotia, Chebucto Light ("Speedwell" Station 118), 53 fms. Approximately ×2.

Figs. 9–10. *Pseudodrifa nigra* (POURTALÈS) from off Georgia ("Albatross" Station 2415), 440 fms. Slightly more than natural size.

PLATE XI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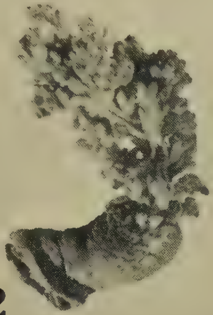
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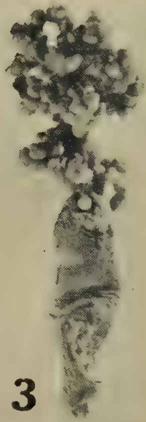
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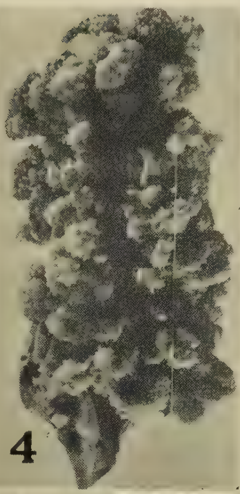
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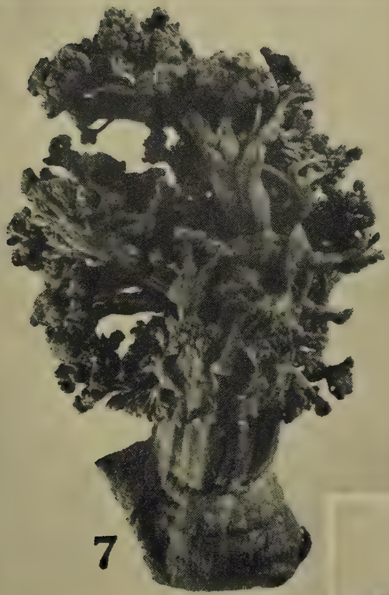
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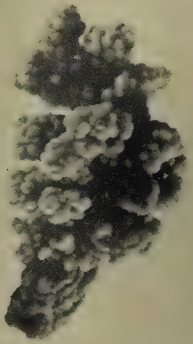
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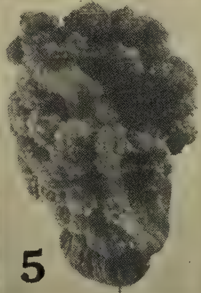
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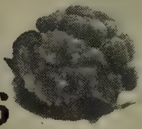
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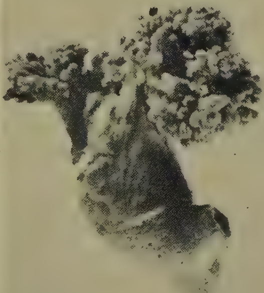
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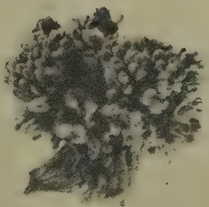
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H. UTINOMI: A REVISION OF NOMENCLATURE OF THE NEPHTHEIDAE, II.

SOME SNOUT MITES FROM JAPAN (ACARINA: BDELLIDAE)[1][2]

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With 37 Text-figures

Bdellid mites, often called snout mites, are known to prey on small arthropods and their eggs. These mites are found in various habitats, *e.g.*, soil, plants, caverns, and intertidal zone of sea shores. There is little information about bdellids from Japan and its adjacent regions (Karsch, 1881; Kishida, 1927, 1935; Thor and Uchida, 1933; Asanuma, 1947; Ehara, 1960a).

In the present paper the following six species are recognized from this country:

Bdella longicornis (Linnaeus)
Bdella uchidai n. sp.
Neomolgus littoralis (Linnaeus)
Thoribdella simplex Atyeo
Thoribdella japonica n. sp.
Bdellodes longirostris (Hermann)

This study is based on a small collection of bdellids taken from several localities in Japan during recent years. The holotypes, allotypes and part of the paratypes of the new species are preserved in the Zoological Institute, Hokkaido University; the remainder of the paratypes are deposited in the personal collection of Dr. Warren T. Atyeo, Department of Entomology, University of Nebraska, Lincoln, Nebraska, U.S.A.

The descriptive terms used are mainly those of Atyeo (1960). When setae are variable individually in number, their numbers are generally given as minimums, maximums, and modes; for example, "8 (7–11)" would indicate that the mode is 8, the minimum is 7, and the maximum is 11. Whenever the minimum and maximum numbers of setae are given in the species of which a single specimen is available, the numbers are different right and left. For the numerous synonymies of the named species, see Thor (1931) and Atyeo (1960).

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1) Contribution No. 513 from the Zoological Institute, Faculty of Science, Hokkaido University, Sapporo, Japan.
2) This work was supported by grants from the Scientific Research Fund of the Ministry of Education.

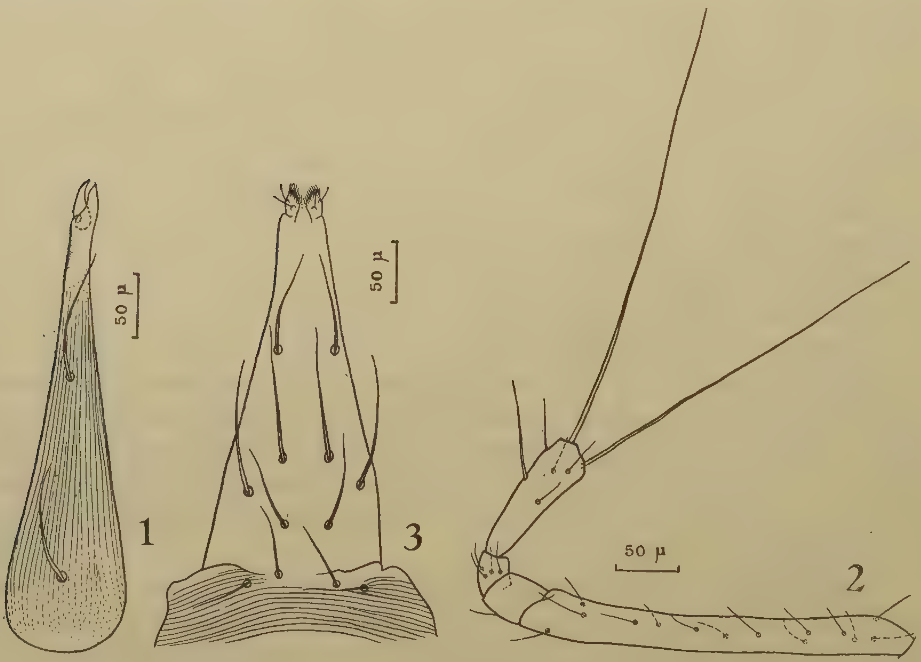
Publ. Seto Mar. Biol. Lab., IX (2), 1961. (Article 13)

Bdella longicornis (LINNAEUS)

(Figs. 1–3)

Acarus longicornis LINNAEUS, 1758, Syst. Nat., ed. 10, p. 618.

Female. Body, including rostrum, 1500μ long. Chelicera (Fig. 1), 400μ long, longitudinally finely striated, with 2 setae; movable digit slightly surpassing fixed digit, both digits smooth on inner surfaces. Palpus (Fig. 2): Segment II, 300μ long, with 14–15 setae; III, 44μ long, with 1 seta; IV, 31μ long, with 4 setae; V, 113μ long, with 7 setae including 1 short sensory seta and 2 macrosetae (369μ and 300μ). Gnathosomal base striated, buccal cone (Fig. 3) finely striated. Ventral hypostomal setae as shown in Fig. 3; dorsal hypostomal setae absent. Legs: Claws with 4–5 lateral rays each. Trochanter I, 78μ long, with 1 tactile seta; basifemur I, 181μ long, with 14 tactiles; telofemur I, 113μ long, with 13–14 tactiles; genu I, 81μ long, with 9 tactiles, 4 slender sensory setae, 1 set of duplex setae; tibia I, 169μ long, with 16 tactiles, 6 slender sensory setae, 1 set of duplex setae, trichoboth; tarsus I, 231μ long, with 14 nude dorsals, 4 plumose dorsoterminals, 16 ventrals (distal ones plumose), 2 broad, blunt and 2 slender sensory setae, 1 peg. Trochanter II, 78μ long, with 1 tactile; basifemur II, 150μ long, with 13 tactiles; telofemur II, 94μ long, with 12–13 tactiles; genu II, 75μ long, with 9 tactiles, 2 slender sensory setae, 1 set of duplex setae; tibia II, 138μ long, with



Figs. 1–3. *Bdella longicornis* (♀). 1, chelicera. 2, palpus. 3, hypostome.

15 tactiles, 1 broad, blunt and 3 slender sensory setae; tarsus II, 213μ long, with 13 nude dorsals, 4 plumose dorsoterminals, 14 ventrals (distal ones plumose), 2 broad, blunt sensory setae, 1 peg. Trochanter III, 100μ long, with 2 tactiles; basifemur III, 194μ long, with 12 tactiles; telofemur III, 113μ long, with 11 tactiles; genu III, 94μ long, with 9 tactiles, 2 slender sensory setae, 1 set of duplex setae; tibia III, 169μ long, with 16 tactiles, 1 slender sensory seta; tarsus III, 269μ long, with 11 nude dorsals, 4 plumose dorsoterminals, 14 ventrals (distal ones plumose), trichoboth. Trochanter IV, 138μ long, with 2 tactiles; basifemur IV, 200μ long, with 6 tactiles; telofemur IV, 125μ long, with 8 tactiles; genu IV, 125μ long, with 10 tactiles, 3 slender sensory setae; tibia IV, 200μ long, with 14 tactiles, trichoboth; tarsus IV, 288μ long, 9 nude dorsals, 4 plumose dorsoterminals, 14 ventrals (distal ones plumose), 1 slender sensory seta, trichoboth. Dorsal integumentary striae on propodosoma finely broken, area between anterior and posterior sensilla with transverse striae; median and lateral propodosomals nude, shorter than posterior sensillum; interval between anterior sensilla, 119μ; distance between two eyes slightly longer than diameter of anterior eye. Dorsal hysterosomal setae apparently nude, long and slender, but shorter than intervals to bases of setae next behind, except for caudal setae reaching to their succeeding bases. Border striae of anal cleft parallel; 1 pair of anal setae and 5 pairs of paranal setae; postanals cephalad of dorsal termination of anal cleft, slightly longer than external clunals. Each genital plate with 8 genital setae; genital discs normal; number of paragenital setae not determined (According to ATYEO, 1960, 9–10 pairs occurring in the New World specimens); ovipositor with 20 setae.

Male. Not available to the author.

Specimen examined. Female, Sapporo, Hokkaido, 10–VII–1958 (on earth), S. Ehara leg.

Distribution. Asia, Europe, North and Central America, and in Japan (*first record*): Hokkaido.

Remarks. Referring to ATYEO's description (1960), the present material is different from his materials in having additional sensory setae on genua III and IV.

Bdella uchidai n. sp.

(Figs. 4–12)

Female.[1] Body (Fig. 4), including rostrum, 1710 [1540] μ long, and 819 [619] μ wide, somewhat purplish red in colour. Chelicera (Fig. 5), 475 [388] μ long, longitudinally finely striated, with 2 setae; movable digit slightly surpassing fixed digit, both digits nearly smooth on inner surfaces. Palpus (Fig. 6): Segment I, 31[29]μ long; II, 331[288]μ long, with 15(13–15)[14] setae; III, 73[44–63]μ long, with 1 seta; IV, 50[38–44]μ long, with 4 setae; V, 169[119–138]μ long, with 7[7–8] setae including 1 short sensory seta and 2 macrosetae (375[250–338]μ and 344[225–313]μ). Gnathosomal base striated, buccal cone (Fig. 7) with striations fine. Ventral hypostomal setae as shown in Fig. 7; dorsal hypostomal setae wanting. Legs (Figs. 11, 12): Claws with 6 lateral rays each. Trochanter I, 113[104]μ, with 2(2–3)[2] tactile setae; basifemur I, 231[213]μ long, with 15 (15–19)[14(13–14)] tactiles; telofemur I, 144[119]μ long, with 13(13–16)[12(12–13)] tactiles, 2(1–2)[0] slender sensory setae; genu I, 106[131]μ long, with 10(9–10) tactiles, 8(6–8)[6] slender sensory setae, 1 set of duplex setae; tibia I, 213[181]μ long, with 16(16–18) tactiles, 6–9[7(6–7)] slender sensory setae, 1 set of duplex setae, trichoboth; tarsus I, 256[219]μ long, with 14 dorsals (2–4 distal ones minutely plumose), 4 plumose dorsoterminals, 16 ventrals (14[14(12–14)] ones

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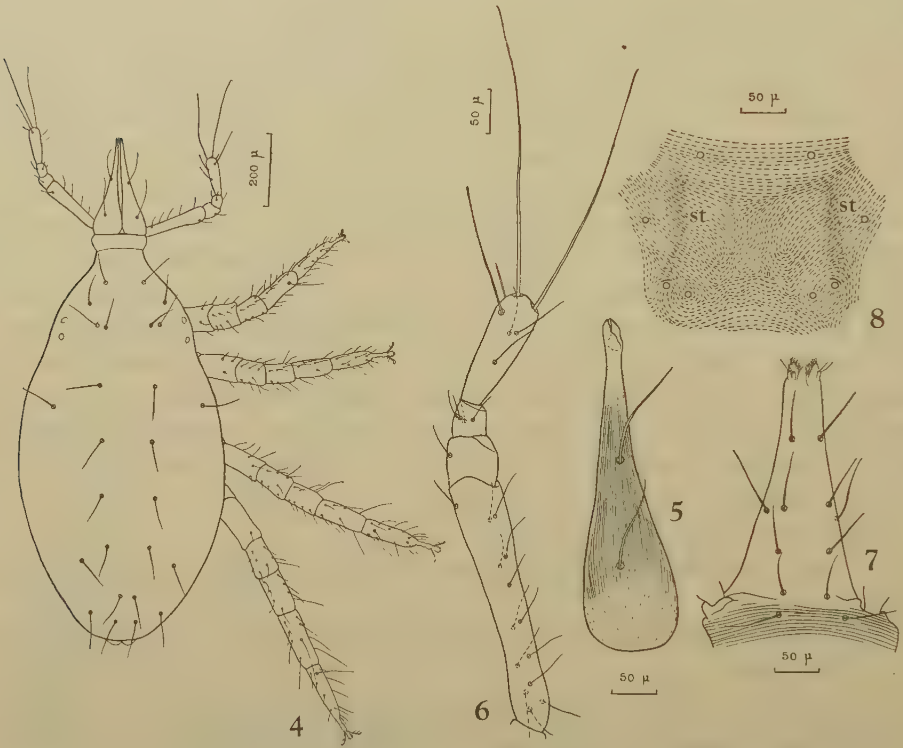
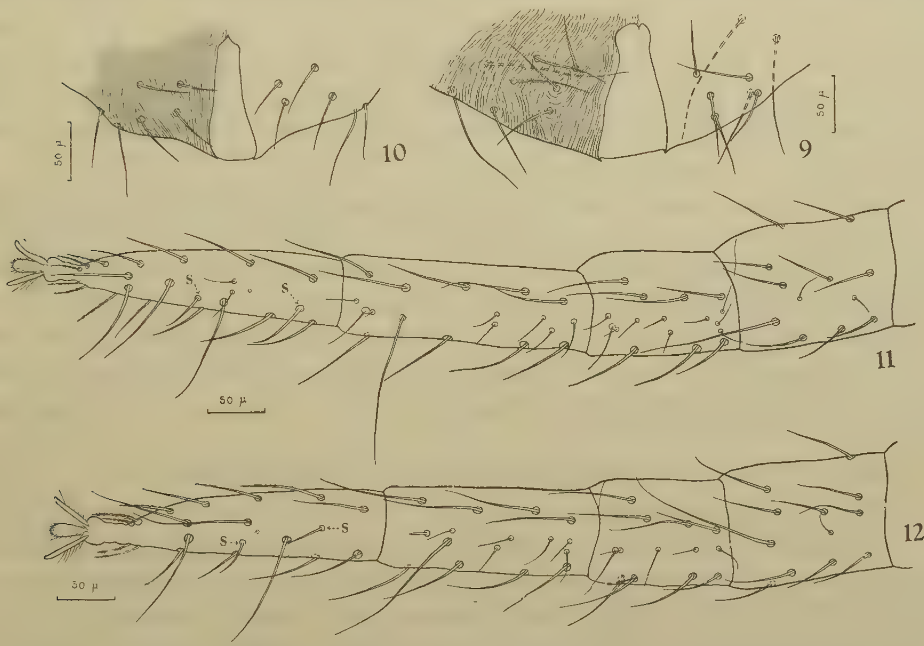
[1] *Bdella uchidai* is variable locally: specimens from Ranshima, Osyoro and Hariusu are considerably different from those from Akkeshi. This description is based on these two groups of specimens; nonbracketed numerical values are data obtained from the former group, while bracketed values are from the latter group. Whenever data from the two groups are identical, a nonbracketed value is only given.



Figs. 4–8. *Bdella uchidai* n. sp. (Akkeshi). 4, dorsal view of body (♂). 5, chelicera (♀). 6, palpus (♀). 7, hypostome (♂). 8, dorsal integumentary striation of propodosoma (♂); st, subcutaneous thickenings.

plumose), 2 broad, attenuate and 2 adjacent, slender sensory setae, 1 peg. Trochanter II, 119[106]μ long, with 2 tactiles; basifemur II, 219[181]μ long, with 13–15[12–14] tactiles; telofemur II, 138[119]μ long, with 14(14–17)[13(12–13)] tactiles, 0(0–1)[0] slender sensory seta; genu II, 125[106]μ long, with 10 tactiles, 3(3–4) slender sensory setae, 1 set of duplex setae; tibia II, 188[163]μ long, with 17(16–17)[17] tactiles, 1 broad, blunt and 6[5] slender sensory setae; tarsus II, 263[219]μ long, with 13 dorsals (1–3 distal ones minutely plumose), 4 plumose dorsoterminals, 14 ventrals (12(11–12)[10–12] ones plumose), 2 broad, attenuate sensory setae, 1 peg. Trochanter III, 163[138]μ long, with 3(3–4)[4] tactiles; basifemur III, 256[219]μ long, with 11–13[12(12–13)] tactiles; telofemur III, 144[125]μ long, with 11–15[10–12] tactiles; genu III, 144[125]μ long, with 11 (10–12)[9–11] tactiles, 3(2–3)[2(2–3)] slender sensory setae, 1 set of duplex setae; tibia III, 231[194]μ long, with 17–20[18–20] tactiles, 1(1–3)[2(2–3)] slender sensory seta; tarsus III, 313[269]μ long, with 11 dorsals (1–2 distal ones minutely plumose), 4 plumose dorsoterminals, 14 ventrals (8[6(6–8)] ones plumose), trichoboth. Trochanter IV, 213[175]μ long, with 3–5[3] tactiles; basifemur IV, 269[238]μ long, with 5–7[5] tactiles; telofemur IV, 169[144]μ long, with 11–15[10–13] tactiles; genu IV, 181[156]μ long, with 9–12[10–11] tactiles, 4(3–4) slender sensory setae; tibia IV, 275[231]μ long, with 20(18–20)[18(17–18)] tactiles, 1(1–2)[1]



Figs. 9–12. *Bdella uchidai* n. sp. 9 & 10, showing variation of chaetotactic pattern of anal region: 9, Ranshima, ♂; 10, Akkeshi, ♀. 11, leg I (Ranshima, ♀); s, attenuate, broad sensory seta. 12, leg II (Ranshima, ♀).

slender sensory seta, trichoboth; tarsus IV, 356 [300] μ long, with 10(10–11) dorsals (0–1 distal one minutely plumose), 4 plumose dorsoterminals, 14(14–16)[14] ventrals (8(8–9) [6 8] ones plumose), 1 slender sensory seta, trichoboth. Dorsal integumentary striae on propodosoma (Fig. 8) finely broken; area between anterior and posterior sensilla with transverse striae anteriorly, with irregularly longitudinal striae centrally, and with transverse (convex) striae posteriorly; internal subcutaneous thickenings (Fig. 8) small in extent; median and lateral propodosomals apparently nude, as long as anterior and posterior sensilla each; interval between anterior sensilla, 138 [119] μ; distance between two eyes as long as diameter of posterior eye. Dorsal hysterosomal setae very finely plumose, shorter than distances to bases of setae next behind, except for caudal setae; sacrals and clunals each arranged in gently curving transverse row. Border striae of anal cleft parallel; 2(2–3) pairs of anal setae and 5(4–5) pairs of paranals (Figs. 9, 10); postanals inserted cephalad of dorsal termination of anal cleft, as long as clunals. Each genital plate with 8–12 genital setae; genital discs normal; 19(16–20) pairs of paragenitals; ovipositor with 20 setae.

Male. Smaller than female and generally similar to that sex. Number of slender sensory setae on legs: telofemur I, 0–2 [0(0–1)]; genu I, 7(5–7) [4 5]; genu II, 4(3–4) [2(2–3)]; tibia II, 5(5–7) [4(4–5)]; tibia III, 2 [1]; genu IV, 4(2–4) [3]; tibia IV, 1(1–2) [0(0–1)]. Number of tactile setae: tibia II, 16(16–17) [15 (14–17)]; basifemur III, 12(11–16) [10–11]; tibia III, 18–20 [15(14–18)]; tibia IV, 18(18–20) [14(14–17)]; tarsus IV, 11(9–11) [9]. Each genital plate with 9–10 genital setae; each amphioid sclerite with 6 anterior, 1 middle (smaller), and 2 posterior setae.

Holotype. Female, Ranshima, Hokkaido, 21–X–1957, M. Mizutani leg.

Allotype. Male, same data as holotype.

Paratypes. Four females and 10 males, same data as holotype; 1 female, Osyoro, Hokkaido, 12–VI–1957, M. Yamada & S. Ozawa leg., 2 females, Hariusu, Hokkaido, 22–V–1958, S. Ehara leg.; 2 females and 2 males, Akkeshi, Hokkaido, 1–V–1957, M. Yamada & K. Mikamo leg., 5 females and 4 males, Akkeshi, 27–VI–1957, S. Ehara leg., 2 females and 3 males, Akkeshi, 28–VI–1957, S. Ehara leg.; 1 male, Hakodate, Hokkaido, 29–V–1957, S. Muramatsu leg.; 3 males, Shirahama, Wakayama Pref., Honshu, 24–II–1955, 18–VII–1955, H. Utinomi leg.

All the types were collected on the rocks or stones in the intertidal zone.

Remarks. Bdella uchidai is similar to *Bdella longicornis* but is different in chaetotactic patterns of the ventral gnathosoma and of the legs, particularly, in having more slender sensory setae on the legs and in having attenuate-broad sensory setae on tarsi I and II rather than blunt sensory setae. Further, this species is distinguished from the latter by irregularly longitudinal striae between the anterior and posterior sensilla, by generally nineteen pairs of paragenital setae, and by longer tactile setae on the palpus (excluding distal macrosetae).

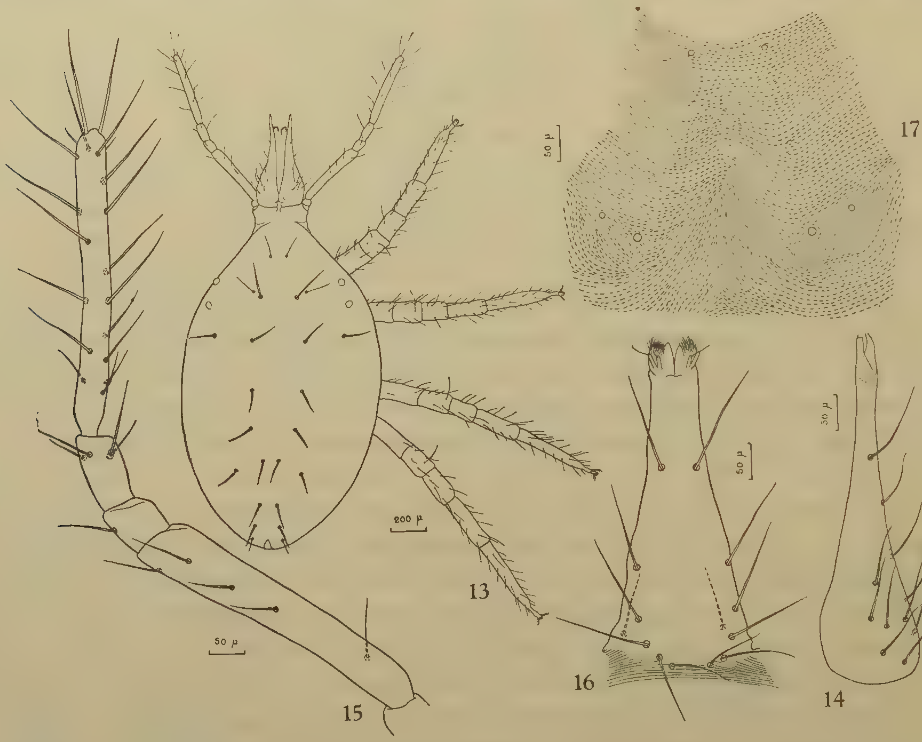
As seen in the above description this species varies locally (cf. foot-notes of page 249). Namely, specimens collected from Ranshima, Osyoro and Hariusu are considerably different from those from Akkeshi. Individuals from Hakodate and Shirahama are so few in number that can not be adequately examined, however they are of the Akkeshi type. On the coasts of Hokkaido, the two bdellid species, *Neomolgus littoralis* and *B. uchidai*, appear to be common; they can be distinguished in the field: the former is dark red in colour, while the latter is somewhat purplish red. This new species is named in honour of Prof. Tohru UCHIDA.

Neomolgus littoralis (LINNAEUS)

(Figs. 13–19)

Acarus littoralis LINNAEUS, 1758, Syst. Nat., ed. 10, p. 618.
Molgus littoralis, THOR & UCHIDA, 1933, p. 138; KISHIDA, 1935, p. 142; TOKUNAGA, 1943, Iyô Kontyûgaku (=*Medical Entomology*), vol. 2, p. 1314.
Biscirus silvaticus (*nec* KRAMER), ASANUMA, 1947, p. 956, Fig. 2719.
Neomolgus littoralis, EHARA, 1960a, p. 9, Pl. 4, Fig. 14; EHARA, 1960b, p. 411.

Female. Body (Fig. 13), including rostrum, 2000–2500μ long, and 775–1190μ wide, dark red in colour. Chelicera (Fig. 14), 556μ long, nonstriated, with 12(10–14) setae; movable digit flattened distally on inner surface, surpassing fixed digit which is remarkably bifurcate apically. Palpus (Fig. 15): Segment I, 44μ long; II, 394μ long, with 5(4–7) setae; III, 69–88μ long, with 1 seta; IV, 106–150μ long, with 4 setae; V, 419μ long, with 20(18–22) setae including 1 short sensory seta and 2 macrosetae (164 and 153μ). Gnathosomal base striated, buccal cone (Fig. 16) nonstriated. Ventral hypostomal setae as shown in Fig. 16; dorsal hypostomal setae as long as, or shorter than *vh* 1. Legs (Figs. 18, 19): Claws with 6–7 lateral rays each. Trochanter I, 144μ long, with 1 tactile seta; basifemur I, 269μ long, with 12–17 tactiles; telofemur I, 144μ long, with 7 tactiles; genu I, 144μ long, with 6(6–7) tactiles, 16(14–23) slender sensory setae; tibia I, 225μ long, with 13(13–17) tactiles, 24(18 30) slender sensory setae, 1 peg, trichoboth; tarsus I, 400μ long, with 14(14–18) nude dorsals, 4 plumose dorsoterminals, 32(26–34) ventrals (19(17–22) ones plumose), 2 broad, blunt and 7–8(6–9) slender sensory setae, 1 peg. Trochanter II, 131μ long, with 1 tactile; basifemur II, 281μ long, with 11–16 tactiles; telofemur II, 144μ long, with 7(7–8) tactiles; genu II, 144μ long, with 6 tactiles, 12(9–17) slender sensory setae; tibia II, 219μ long, with 11–15 tactiles, 1 broad, blunt and 17(14–21) slender sensory setae, trichoboth; tarsus II, 400μ long, with 14(13–17) nude dorsals, 3 plumose and 1 nude (sometimes, slightly plumose only proximally) dorsoterminals, 29(24–34) ventrals (16(13–18) ones plumose), 2 broad, blunt and 2–7 slender sensory setae, 1 peg. Trochanter III, 144μ long, with 1(1–3) tactile; basifemur III, 319μ long, with 12(10–13) tactiles; telofemur III, 156μ long, with 6(6–7) tactiles; genu III, 150μ long, with 6(6–7) tactiles, 8(7–10) slender sensory setae; tibia III, 244μ long, with 15(13–17) tactiles, 4(4–9) slender sensory setae; tarsus III, 450μ long, with 12(11–12) nude dorsals, 2 plumose and 2 nude dorsoterminals, 29(25–34) ventrals (11–13 ones plumose), 0(0–3) slender sensory seta, trichoboth. Trochanter IV, 213μ long, with 3(2–4) tactiles; basifemur IV, 338μ long, with 6(5–8) tactiles; telofemur IV, 181μ long, with 6(6–8) tactiles; genu IV, 200μ long, with 8(6–8) tactiles, 5(4–7) slender sensory setae; tibia IV, 325μ long, with 16(13–17) tactiles, 3–4(0–4) slender sensory setae, trichoboth; tarsus IV, 488μ long, with 11(9–12) nude dorsals, 2 plumose and 2 nude dorsoterminals, 20–29 ventrals (7(6–8) ones plumose), 0(0–1) slender sensory seta, trichoboth. Dorsal integumentary striae on propodosoma (Fig. 17) finely broken; area between anterior and posterior sensilla with transverse striae anteriorly, and with longitudinal striae posteriorly; median propodosomal setae apparently nude, longer than anterior and posterior sensilla each, interval between anterior sensilla, 94μ; lateral propodosomals absent; distance between two eyes twice to three times as long as diameter of anterior eye. Dorsal hysterosomal setae finely plumose, shorter than distances to bases of setae next behind, except for caudal pairs. Border striae of anal cleft parallel; anal setae absent; paranals one-paired;

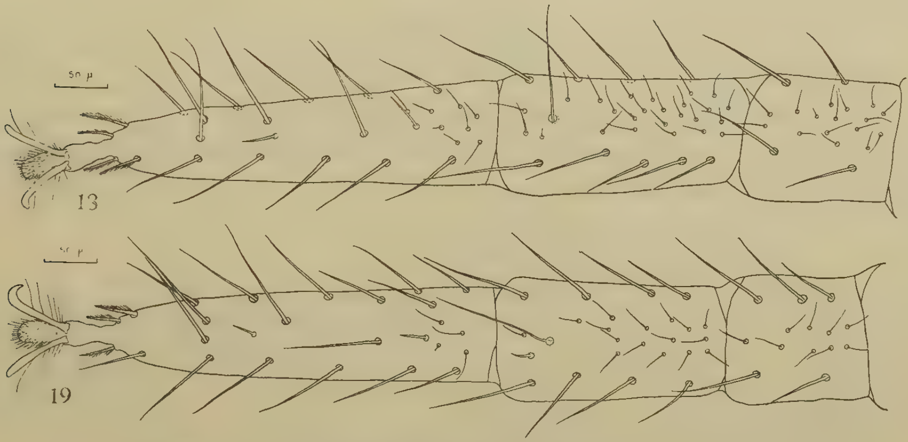


Figs. 13–17. *Neomolgus littoralis*. 13, dorsal view of body (♂). 14, chelicera (♀). 15, palpus (♀). 16, hypostome (♀). 17, dorsal integumentary striation of propodosoma (♂).

postanals inserted at level of dorsal termination of anal cleft, shorter than clunals. Each genital plate with 12(8–12) genital setae; genital discs large; paragenital setae seven-paired (2 anterior, 2 middle and 3 posterior); ovipositor with 20 setae.

Male. Smaller than female and generally similar to that sex. Ventral hypostomal setae six-paired but sometimes five-paired. Slender sensory setae on leg I varying in number more widely than in female; maximum number (loc. Akkeshi) of these setae: genu, 25; tibia, 31; tarsus, 11. Genu II with 6–7 tactiles. Each genital plate with 10(10–16) genital setae; each amphioid sclerite with 3 anterior, 4 middle, and 2 posterior setae (sometimes with 4 anterior, 3 middle, and 2 posterior setae).

Specimens examined. Two females and 1 male, Osyoro, Hokkaido, 12–VI–1957, M. Yamada & S. Ozawa leg., 2 females, Osyoro, 25–VI–1957, Y. Akahira & Z. Nagao leg.; 2 females and 4 males, Akkeshi, Hokkaido, 27–VI–1957, S. Ehara leg., 1 female, Akkeshi, 28–VI–1957, S. Ehara leg.; 2 females, Hakodate, Hokkaido, 29–V–1957, S. Muramatsu leg.; 3 males, Hayama, Kanagawa Pref., Honshu, 21–III–1957, T. Uchida leg.; 1 female, Usa, Kôchi Pref., Shikoku, 15–IV–1961, K. Morikawa leg.



Figs. 18, 19. *Neomolgus littoralis* (♀). 18, leg I. 19, leg II.

The specimens were collected on stones and rocks and under seaweeds in the intertidal zone.

Distribution. Circumpolar. In Japan and its adjacent regions: the Island Alaid, Japan (Hokkaido, Honshu, Shikoku), and Formosa(?).

Remarks. Specimens from Hakodate, Hayama and Usa differ from those from Osyoro and Akkeshi in having one to three slender sensory setae on tarsus III instead of no sensory setae. Tarsus IV of the former is generally lacking sensory seta but rarely having one sensory seta (tarsus IV of the latter is always deficient in sensory setae). As regards the palpal chaetotaxy this species also varies locally; specimens from Hayama and Usa have more than four tactile setae on segment IV, while those from Osyoro, Akkeshi and Hakodate constantly bear four tactile setae. Referring to Atyeo's description (1960), specimens from Osyoro and Akkeshi are considerably different from his materials in having constantly four setae on palpal segment IV, in having more slender sensory setae on leg I and genu II, and in lacking sensory setae on tarsi III and IV.

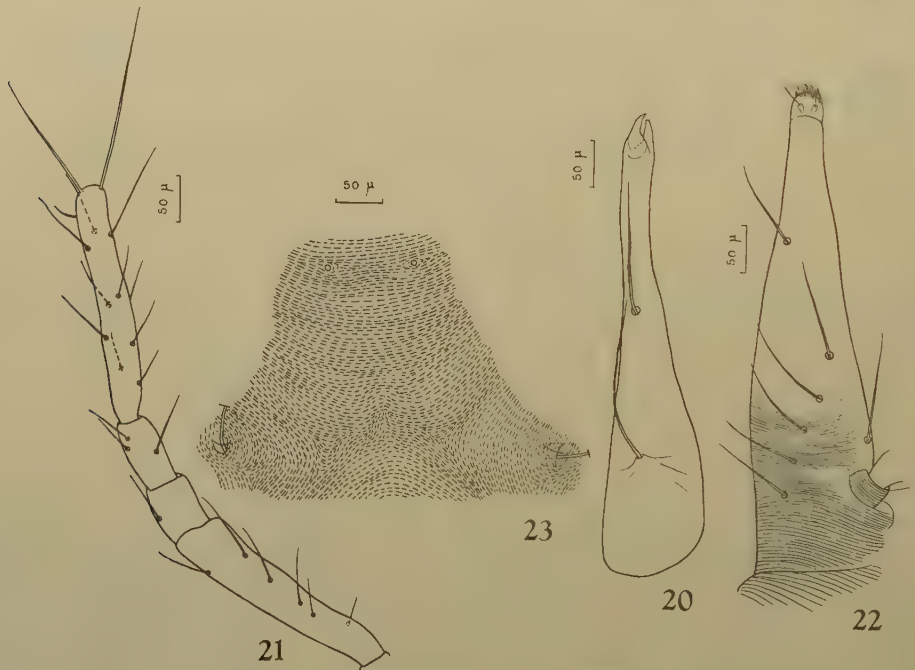
This species has been recorded several times from Japan and its adjacent regions. Thor and Uchida (1933) recorded the mite from Alaid, the northernmost island of the Kurile Islands, while Kishida (1935) from Formosa, as well as from Kanagawa Prefecture and Wakayama Prefecture. The present author is slightly doubtful that Kishida's specimens from Formosa, a subtropical island, were determined correctly.

Thoribdella simplex Atyeo

(Figs. 20–25)

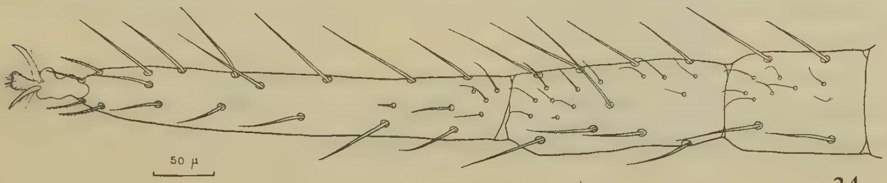
Thoribdella simplex Atyeo, 1960, p. 405, Figs. 8, 23, 49, 103, 104, 147.

Female. Body, including rostrum, 2560μ long. Chelicera (Fig. 20), 488μ long, nonstriated, with 2 setae; movable digit with inner surface flattened distally, surpassing fixed digit which is smooth on inner surface. Palpus (Fig. 21):



Figs. 20–23. *Thoribdella simplex* (♀). 20, chelicera. 21, palpus. 22, hypostome. 23, dorsal integumentary striation of propodosoma.

Segment I, 37μ long; II, 250μ long, with 5-6 setae; III, 66μ long, with 1 seta; IV, 75μ long, with 3 setae; V, 250μ long, with 13-14 setae including 1 short sensory seta and 2 macrosetae (190 and 175μ). Gnathosomal base striated, buccal cone (Fig. 22) striated only proximally. Ventral and dorsal hypostomal setae as shown in Fig. 22. Legs (Figs. 24, 25): Claws with 7-8 lateral rays each. Trochanter I, 113μ long, with 1 tactile seta; basifemur I, 275μ long, with 17 tactiles; telofemur I, 125μ long, with 10 tactiles; genu I, 113μ long, with 6 tactiles, 8 slender sensory setae; tibia I, 175μ long, with 15 tactiles, 11 slender sensory setae, 1 peg, trichoboth; tarsus I, 381μ long, with 13 nude dorsals, 4 plumose dorsoterminals, 44 ventrals (26 ones plumose), 2 broad, blunt and 3 slender sensory setae, 1 peg. Trochanter II, 125μ long, with 1 tactile; basifemur II, 313μ long, with 15-17 tactiles; telofemur II, 125μ long, with 10-11 tactiles; genu II, 119μ long, with 6 tactiles, 5-6 slender senosory setae; tibia II, 188μ long, with 14-15 tactiles, 1 broad, blunt and 5-7 slender sensory setae, trichoboth; tarsus II, 406μ long, with 15-16 nude dorsals, 4 plumose dorsoterminals, 40-43 ventrals (25-27 ones plumose), 2 broad, blunt and 2 slender sensory setae, 1 peg. Trochanter III, 150μ long, with 1-2 tactiles; basifemur III, 325μ long, with 10-13 tactiles; telofemur III, 150μ long, with 8-9 tactiles; genu III, 131μ long, with 6 tactiles, 5-6 slender sensory setae; tibia III, 238μ long, with 18 tactiles, 3 slender sensory setae; tarsus III, 444μ long, with 13 nude dorsals, 4 plumose dorsoterminals, 42-43 ventrals (20-23 ones plumose), trichoboth. Trochanter IV, 200μ long, with 1-2 tactiles; basifemur IV, 348μ long, with 8-9 tactiles; telofemur IV, 175μ long, with 8 tactiles; genu IV, 169μ long, with 7-8 tactiles, 5-7 slender sensory setae; tibia IV, 281μ long, with 22 tactiles, trichoboth; tarsus IV, 488μ long, with 13 nude dorsals, 4 plumose dorsoterminals, 37-38 ventrals (15-16 ones plumose), trichoboth. Dorsal integumentary striae on propodosoma (Fig. 23) finely broken; area between anterior and posterior sensilla



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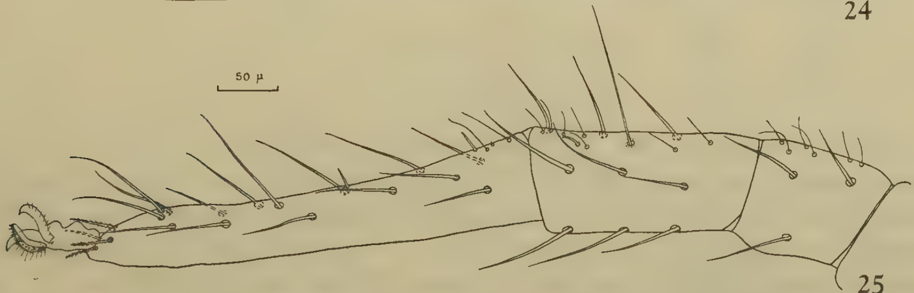


25

Figs. 24, 25. *Thoribdella simplex* (♀). 24, leg I. 25, leg II.

with concave, transverse striae on anterior and middle portions, and with convex, transverse striae on post-medial portion; posterior sensilla, 14μ long, approximate to median propodosomals which are nude, 313μ in length; distance between anterior sensilla, 94μ; lateral propodosomals wanting; interval between two eyes longer than diameter of anterior eye. Dorsal hysterosomals finely plumose, much shorter than intervals to bases of setae next behind, except for external clunals barely reaching to postanals; internal humeral about two-fifth as long as distance to internal dorsal. Border striae of posterior anal cleft parallel; one pair of anal setae; paranals absent; postanals about flanking dorsal termination of anal cleft, as long as clunals. Each genital plate with 8 genital setae; genital discs normal; paragenital setae three-paired; ovipositor with 20 setae.

Male. Not available to the author.

Specimen examined. Female, Takanegahara (ca. 1800 m height above the sea), Mt. Daisetsu, Hokkaido, 5-VIII 1960 (under stone), S. F. Sakagami, K. Moriya & M. Shiokawa leg.

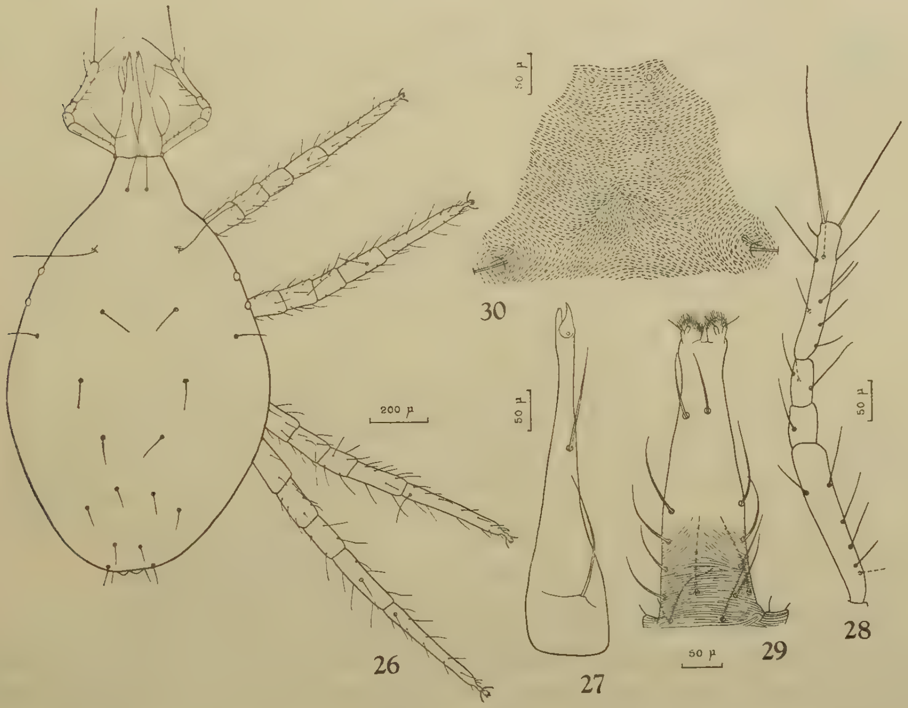
Distribution. U.S.A.; Japan (*first record*): Hokkaido.

Remarks. This identification is confirmed by Dr. Atyeo. It is known that, in U.S.A., the species is extremely variable locally (Atyeo, 1960).

Thoribdella japonica n. sp.

(Figs. 26–32)

Female. Body (Fig. 26), including rostrum, 1940μ long and 890μ wide, pale red in colour. Chelicera (Fig. 27), 438μ long, nonstriated, with 2 setae; movable digit flattened distally on inner surface, much surpassing the fixed digit which is smooth on inner surface. Palpus (Fig. 28): Segment I, 25μ long; II, 213μ long, with 5–6 setae; III, 59μ long, with 1 seta; IV, 59μ long, with 3 setae; V, 181μ long, with 11 setae including 1 short sensory seta and 2 macrosetae (206μ and 156μ). Gnathosomal base striated, buccal cone (Fig. 29) striated proximally. Ventral hypostomal setae as shown in Fig. 29; dorsal hypostomals as long as, or longer than *vh* 5, and longer than *vh* 1–4 and *vh* 6. Legs (Figs. 31, 32): Claws with 6–13 lateral rays each. Trochanter I, 119μ long, with 1 tactile seta; basifemur I, 244μ long, with 15–17 tactiles; telofemur I, 125μ long, with 10 tactiles; genu I, 106μ long, with 6(6–7) tactiles, 7(7–8) slender sensory setae; tibia I, 150μ long, with 12(11–12) tactiles, 9(8–10) slender sensory setae, 1 peg, trichoboth; tarsus I, 319μ long, with 13 nude dorsals, 4 plumose dorsoterminals, 47(42–47) ventrals (29–33 ones minutely plumose), 2 broad, blunt and 2 slender sensory setae, 1 peg. Trochanter II, 125μ long, with 1 tactile; basifemur II, 256μ long, with 14–16 tactiles; telofemur II, 119μ long, with 10 tactiles; genu II, 113μ long, with 6 tactiles, 4(4–5) slender sensory setae; tibia II, 163μ long, with 12(11–12) tactiles, 1 broad, blunt and 6(5–6) slender sensory setae, trichoboth; tarsus II, 344μ long, with 13 nude dorsals, 4 plumose dorsoterminals, 44–50 ventrals (30(29–30) ones minutely plumose), 2 broad, blunt and 1 slender sensory setae, 1 peg. Trochanter III, 134μ long, with 1 tactile; basifemur III, 281μ long, with 11(10–12) tactiles; telofemur III, 131μ long, with 8 tactiles; genu III, 119μ long, with 6 tactiles, 4 slender sensory setae; tibia III, 200μ long, with 13(12 14) tactiles, 1 slender sensory seta; tarsus III, 400μ long, with 11 nude dorsals, 4 plumose dorsoterminals, 42–46 ventrals (23 27 ones minutely plumose), trichoboth. Trochanter IV, 181μ long, with 1 tactile; basifemur IV, 331μ long, with 5(5 6) tactiles; telofemur IV, 163μ long, with 8(8-9) tactiles; genu IV, 156μ long, with 6(6–7) tactiles, 4(4–5) slender sensory setae; tibia IV, 256μ long, with 13(13–16) tactiles, trichoboth; tarsus IV, 425μ long, with 9(9–10) nude dorsals, 4 plumose dorsoterminals, 34–39 ventrals (14–16 ones minutely plumose), trichoboth. Dorsal integumentary striae on propodosoma (Fig. 30) finely broken, area between anterior and posterior sensilla striated as figured; anterior sensilla, 150μ long, posterior senilla, 31μ long, approximate to median propodosomals which are nude, 300μ in length; distance between anterior sensilla, 75μ; lateral propodosomals absent; interval between two eyes about twice as long as diameter of anterior eye. Dorsal hysterosomal setae finely plumose, much shorter than intervals to bases of setae next behind, except for



Figs. 26–30. *Thoribdella japonica* n. sp. (♀). 26, dorsal view of body. 27, chelicera. 28, palpus. 29, hypostome. 30, dorsal integumentary striation of propodosoma.

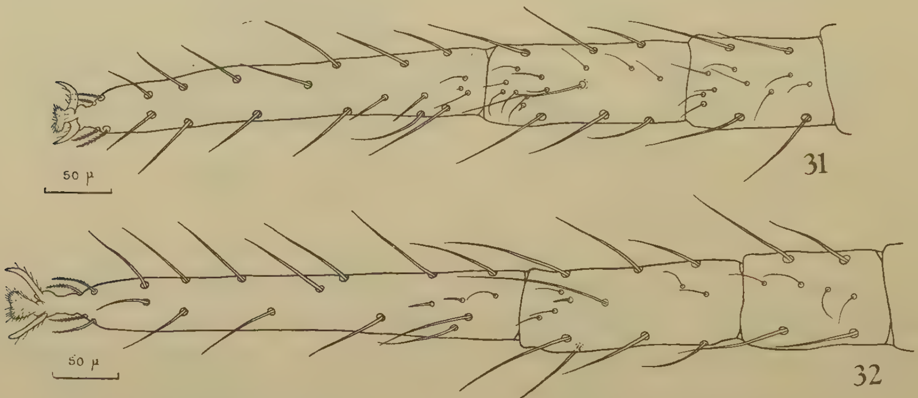
clunals reaching to their succeeding bases; sacrals arranged in gently curving transverse row, clunals in strongly curving row. Border striae of anal cleft parallel; anal setae one-paired; paranal setae lacking; postanals inserted at level slightly caudad of dorsal termination of anal cleft, shorter than clunals. Each genital plate bearing 8 genital setae; genital discs normal; paragenital setae three-paired; ovipositor with 20 setae.

Male. Smaller than female. Each amphioid sclerite with 3 anterior, 4 middle, and 2 posterior setae.

Holotype. Female, Sapporo, Hokkaido, 8-IX-1959 (on ezo-spruce), S. EHARA leg.

Allotype. Male, same data as holotype.

Paratypes. Six females, same data as holotype; 1 female, 26-VIII-1959, other data same as in holotype.



Figs. 31, 32. *Thoribdella japonica* n. sp. (♀). 31, leg I. 32, leg II.

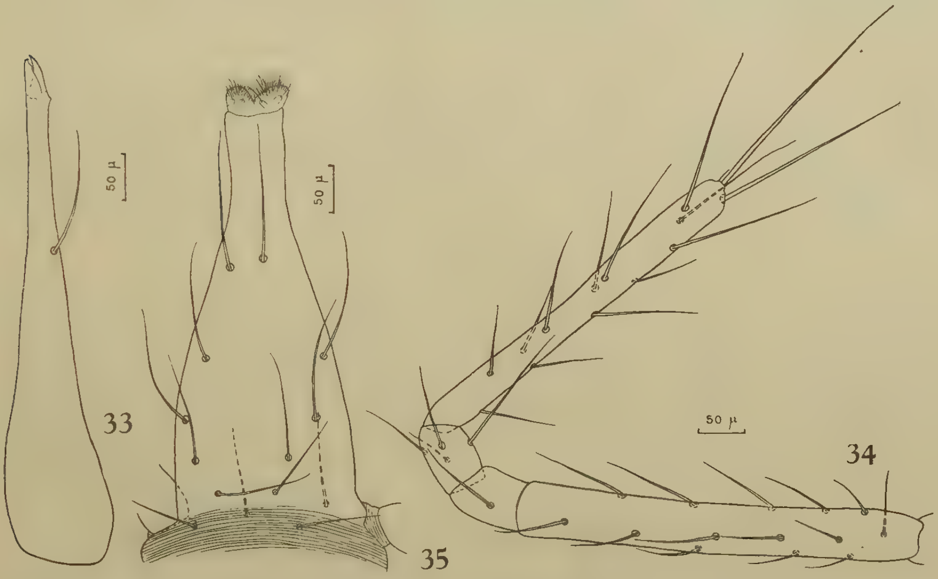
Remarks. This new species appears to be similar to *symmetricus* KRAMER and *lapidarius* KRAMER, both of which belong to the genus *Thoribdella* (ATYEO, *in litt.*). The new species is distinguished from *symmetricus* by the relative lengths of palpal segments II and V, and by the relative lengths of palpal macrosetae (THOR, 1931; WOMERSLEY, 1933). This species is different from *lapidarius* in the relative lengths of two cheliceral setae, and in the relative lengths of segment V and macrosetae of palpus (THOR, 1931; WOMERSLEY, 1933; BAKER and BALOCK, 1944).

Bdellodes longirostris (HERMANN)

(Figs. 33–37)

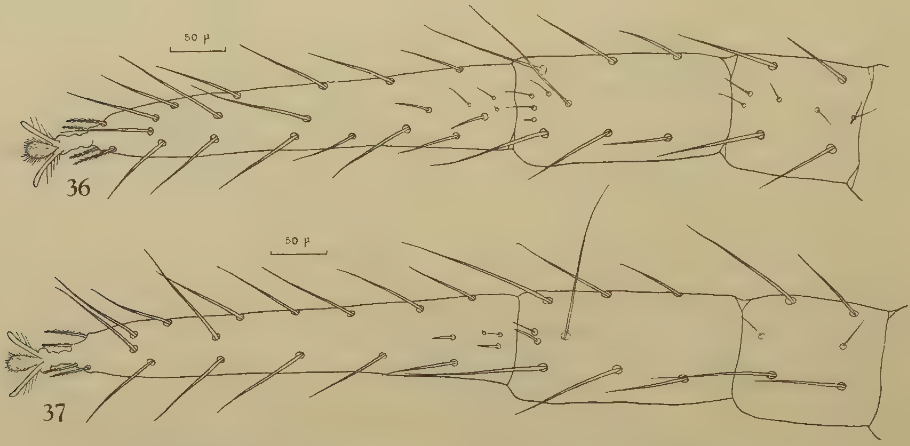
Scirus longirostris HERMANN, 1804, Mém. Apt., p. 62.
Scirus longitarsa (*nec* KARSCH), KISHIDA, 1927, p. 975, Fig. 1877; KISHIDA, 1947, Illustr. Encycl. Fauna Jap., Rev. Ed., p. 955, Fig. 2718.

Male. Body, including rostrum, 2190μ in length. Chelicera (Fig. 33), 569μ long, nonstriated, with 1 seta; movable digit with a preapical tooth, slightly surpassing fixed digit which is provided with a prominent preapical tooth. Palpus (Fig. 34): Segment I, 38μ long; II, 438μ long, with 13–14 setae; III, 83μ long, with 1 seta; IV, 80μ long, with 4 setae; V, 412μ long, with 15 setae including 1 short sensory seta and 2 macrosetae (266 and 244μ). Gnathosomal base striated, buccal cone (Fig. 35) nonstriated. Ventral hypostomal setae as shown in Fig. 35; dorsal hypostomal setae as long as *vh* 2. Legs (Figs. 36, 37): Claws with 6–7 lateral rays each. Trochanter I, 138μ long, with 1 tactile seta; basifemur I, 288μ long, with 14 15 tactiles; telofemur I, 131μ long, with 7 tactiles; genu I, 125μ long, with 6 tactiles, 4–5 slender sensory setae; tibia I, 194μ long, with 12 tactiles, 3 slender sensory setae, 1 peg, trichoboth; tarsus I, 425μ long, with 13–15 nude dorsals, 4 plumose dorsoterminals, 37 plumose ventrals (the more proximal ones the less plumose), 2 broad, blunt and 2 slender sensory setae, 1 peg. Trochanter II, 138μ long, with 1 tactile; basifemur II, 281μ long, with 14–15 tactiles; telofemur II, 138μ long, with 7 tactiles; genu II, 125μ long, with 6 tactiles, 2–3 slender sensory setae; tibia II, 200μ long, with 12 tactiles, 1 broad, blunt and 1 slender sensory setae, trichoboth; tarsus II, 438μ long, with 13–14 nude dorsals, 4 plumose dorsoterminals, 36–38 plumose ventrals (the more proximal ones the less plumose), 2 broad, blunt and 1 slender sensory setae, 1 peg. Trochanter III, 144μ long, with 1 tactile; basifemur III, 350μ long, with 12 tactiles; telofemur III, 150μ



Figs. 33–35. *Bdellodes longirostris* (♂). 33, chelicera. 34, palpus. 35, hypostome.

long, with 6 tactiles; genu III, 144μ long, with 6 tactiles, 2 slender sensory setae; tibia III, 250μ long, with 12 13 tactiles, 1 slender sensory seta; tarsus III, 494μ long, with 11–12 nude dorsals, 4 plumose dorsoterminals, 33–34 plumose ventrals (the more proximal ones the less plumose), trichoboth. Trochanter IV, 206μ long, with 1 tactile; basifemur IV, 381μ long, with 5 tactiles; telofemur IV, 169μ long, with 6 tactiles; genu IV, 169μ long, with 5 tactiles, 2 slender sensory setae; tibia IV, 306μ long, with 11–13 tactiles, trichoboth; tarsus IV, 525μ long, with 10 nude dorsals, 4 plumose dorsoterminals, 27 plumose ventrals (the more proximal ones the less plumose), trichoboth. Dorsal integumentary striae on propodosoma finely broken; median propodosomals inconspicuously plumose, as long as anterior and posterior sensilla each, interval between anterior sensilla, 88μ; lateral propodosomals absent; distance between two eyes more than twice as long as diameter of anterior eye. Dorsal hysterosomal setae finely plumose, shorter than intervals to bases of setae next behind, except for caudal pairs. Border striae of anal cleft parallel; 1 pair of anal setae; paranals absent; postanals inserted at level slightly caudad of dorsal termination of anal cleft, shorter than clunals. Each genital plate with 6 genital setae; middle and posterior genital discs adjacent on each side; number of paragenital setae not determined (According to ATYEO, 1960, 4–5 pairs located in the New World specimens); each amphioid sclerite with 3 anterior, 4 middle, and 2 posterior setae.



Figs. 36, 37. *Bdellodes longirostris* (♂). 36, leg I. 37, leg II.

Female. Not available to the author.

Specimen examined. Male, Sapporo, Hokkaido, 2–VII–1958 (on earth), S. EHARA leg.

Distribution. Asia, Europe, North, Central and South America, Australia. In Japan (*first record*): Hokkaido, Honshu, Shikoku, Kyushu.

Remarks. It is of interest that, referring to ATYEO's illustrations (1960), two broad, blunt sensory setae on tarsi I and II are different in position between the New World and the Japanese specimens. These setae of the latter are located on the proximal portion of each tarsus, rather than on the middle portion.

From Honshu, Shikoku and Kyushu, a mite was recorded by KISHIDA (1927) under the name *Scirus longitarsa* (KARSCH). Judging from his illustration, it is almost certain that the mite is really *Bdellodes longirostris*.

Acknowledgements

The author wishes to thank Professor Tohru UCHIDA whose encouragement has constantly been offered. Sincere thanks are due to Dr. Warren T. ATYEO who carefully examined some of the present material and kindly reviewed the manuscript of this paper. Further, acknowledgement is made to Dr. Huzio UTINOMI, Dr. Kuniyasu MORIKAWA, Mr. Hiroyuki KAMIYA and Dr. Mayumi YAMADA for their kindness during the course of this study. The author is also indebted to the several collectors named in the text.

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NIPPONOMONTACUTA ACTINARIOPHILA Gen. et Sp. Nov., A NEW COMMENSAL BIVALVE OF THE SEA ANEMONE[1]

Torao YAMAMOTO and Tadashige HABE

Seto Marine Biological Laboratory (Kyoto University) and Amakusa Marine Biological Laboratory (Kyushu University)

With 2 Tex-figures

Last summer, a small bivalve was collected by the senior author from the surface of the sea anemone whose scientific name was not yet determined, on the rocky shore near the Seto Marine Biological Laboratory and the commensal habit of this interesting bivalve has been observed by him. This is new to science. Therefore this is described on the following lines.

Nipponomontacuta actinariophila gen. et sp. nov.

(Text-figs. 1, 2)

Shell small, ovate in shape, inequilateral, the anterior half somewhat smaller and narrower than the posterior, but equivalve, reddish rose in colour, especially deeply coloured in the umbonal area; each valve moderately convex and umbo slightly prominent beyond the dorsal margin and somewhat prosogyrate; dorsal margin nearly straight; anterior dorsal margin shorter than the posterior; anterior margin roundly arcuated and the posterior subtrucated; the ventral gently curved; surface covered with the rough brownish yellow periostracum which is deciduous at the umbonal area and marks several radial cords from the umbo to the antero-ventral margin and sculptured with the growth lines which sometimes become strong as the resting stages; hinge plate rather thick and broad; hinge of the left valve with two stout diverging teeth, the anterior tooth shorter and stronger than the posterior, between them a resilifer present; in the right valve the extension of the dorsal margin is fixed the pits between the cardinal teeth and the anterior and posterior dorsal margins in the left valve; mantle line connected the anterior muscle scar with the posterior is simple, not present any sinuation

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1) Contributions from the Seto Marine Biological Laboratory, No. 370 and Contributions from the Amakusa Marine Biological Laboratory (Kyushu University), No. 157.

Publ. Seto Mar. Biol. Lab., IX (2), 1961. (Article 14)

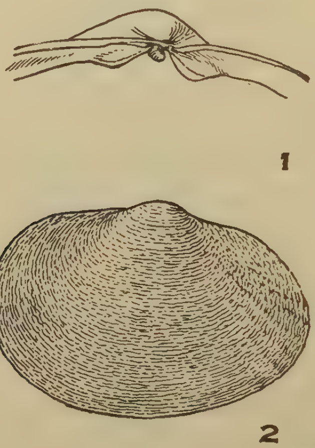
at the posterior end; ventral margin flat and not crenulated.

Length 4.0 mm, height 3.0 mm, breadth 1.8 mm (conjoined type specimen)

Length 4.1 mm, height 3.1 mm, breadth 0.9 mm (left valve collected from off Tomioka, Amakusa, Kumamoto Pref., Kyushu)

Type locality: Bansyo-zaki, Shirahama, Wakayama Pref., Honshu.

Remarks: A new genus, *Nipponomontacuta*, established for this interesting species, resembles *Montacuta* Turton, but the former has the ovate shell the umbo of which is situated nearly midway between the anterior and dorsal margins and with the very stout cardinal teeth in the left valve and the interior is surrounded by the narrow flat margin. Moreover, theshell is covered by the rough thick periostracum. In the genus, *Montacutona* HABE, the surfuce of the shell is smooth and the umbo is oblique forwards and is rather nearer to the anterior than to the posterior end.



Figs. 1, 2. *Nipponomontacuta actinariophila* gen. et sp. nov.

1. hinge teeth in the left valve, 2. right valve.

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THE STRUCTURE OF THE OPERCULUM OF THE SPECIES OF ATLANTIDAE (GASTROPODA: HETEROPODA) AS A TAXONOMIC CRITERION, WITH RECORDS OF SOME PELAGIC MOLLUSKS IN THE NORTH PACIFIC[1]

TAKASI TOKIOKA

Seto Marine Biological Laboratory, Sirahama

With 42 Text-figures and 22 Tables

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1) Contributions from the Seto Marine Biological Laboratory, No. 371.

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Introduction

The toxonomic criteria for the species of the Family Atlantidae of Heteropoda (Gastropoda) have been based chiefly on structures or features of the shell. Indeed, these criteria are distinct for a few species: *Atlanta lesueuri*, *A. fusca*, *A. turriculata*, *A. inclinata*, and *Oxygylus keraudreni*; but they are so exact for other species, including their jeveniles and those of some of the above-mentioned species, that sometimes the identification is made only provisionally without any confidence. Especially, the juveniles of Atlantidae are mostly left without any definite identification. To improve such a circumstance even a little, I tried to show a part of the morphological characters of the shell by means of numerical representations (1955 a). This is, however, still insufficient, and moreover it cannot be applied for specimens, the shells of which are softened in some inadequate states of preservation.

While I was examining many plankton samples, especially of the Shellback Expedition, at the Scripps Institution of Oceanography in 1956–1957, I found so many softened shells of Atlantidae in those samples and was urged to find out some way to identify them to record the occurrences of respective species. Examining these softened shells under the binocular, I found that the operculum could be removed rather easily off these specimens and began to study the morphology of the operculum in a hope to get any definite criterion for identification. Evidently, some species are provided respectively with a quite unique operculum, while the operculum structures in others are related one another rather closely, although they seem to be helpful for identification. It was found that *Atlanta inflata* can be identified very easily and distinctly by the structure of the operculum. For other species, it is very effective to examine the operculum to ascertain the identification. An effort was made to support the validity of *Atlanta pacifica*, which I separated from *A. gaudichaudi* on the basis of the difference found in the whorl formula, by examining closely the operculum, but this was not successful. I am unhappy but have to admit that the validity of my *A. pacifica* is doubtful.

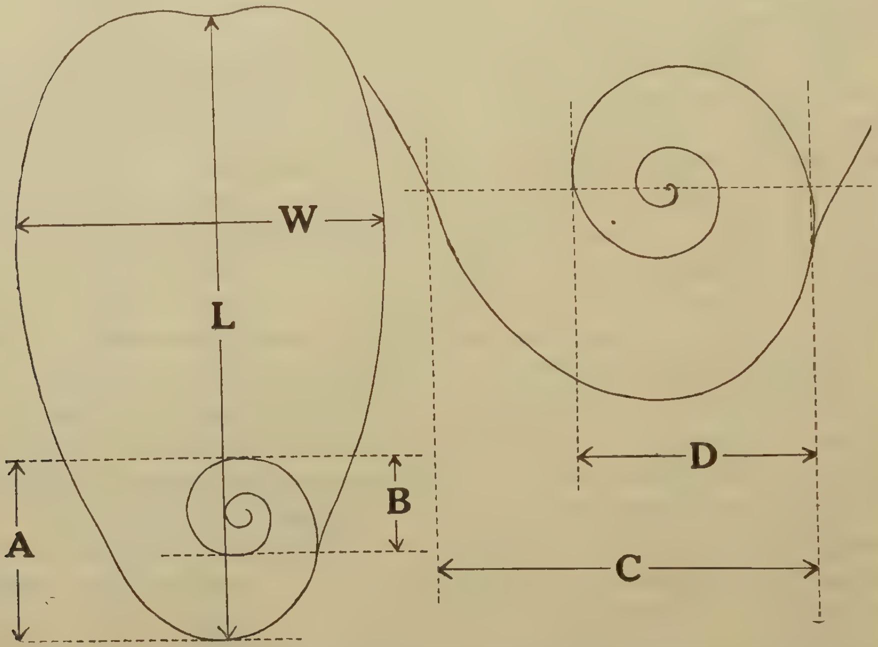
In addition to the descriptions of the operculum of respective species of Atlantidae, occurrences of some pteropods and heteropods other than Atlantidae in the North Pacific are recorded in this paper together with some brief morphological notes.

Before going further, I want to express my hearty thanks to the staff of the Scripps Institution of Oceanography, who granted me a favour to have a seat at the laboratory for a year, especially to Prof. W. M. JOHNSON for his kindness in providing all kinds of facilities, and also to the ROCKEFELLER Foundation for the postdoctoral grant.

I. General structure of the operculum in Atlantidae

The operculum is an oval plate, quite colourless, transparent and very thin in most species. The outline of the operculum shows approximately the shape of the shell aperture. They are usually so thin that they can be examined with some difficulties under the usual microscope as in *A. lesueuri*, *A. inclinata* and some others; in such specimens, the staining by rose bengal is somewhat helpful for examination. *A. turriculata* and *A. fusca* have rather thick operculum.

The operculum shows a spiral structure coiled sinistrally, the distal portion of which is remarkably widened and forms the major part of the operculum on the axial side, while the initial part of the spiral remains as a smaller gyre on the peripheral side of the operculum.



Text-fig. 1. Schemata showing the measurements referred in this paper. For captions see the text on this page. The operculum is figured as seen from the attachment surface. Top shows the axial side and bottom indicates the peripheral side. The right side corresponds to the lower or anterior side of the shell aperture, while the left fits to the upper or posterior side of the aperture.

The proportional size of the gyre and the situation of the centre of the gyre seem to differ specifically. And, in order to show these features exactly, the following measurements were made on nearly the whole opercula examined:

L···long diameter, or length (lateral) of operculum
W···short diameter, or width (antero-posterior) of operculum
A···length of gyre, or the distance between the outer (peripheral) edge of the operculum and the inner (axial) margin of the gyre
B···longitudinal diameter of the central part of the gyre, or the distance between the inner (axial) margin of the gyre and the outer margin of the penultimate whorl of the gyre
C···width (antero-posterior) of the gyre at the level of its centre
D···width of the gyre excluding the last whorl at the same level as in C.

Evidently, both W/L and A/L decrease with growth. Originally, the gyre is considered to grow a little with age, but the lower (peripheral) margin of this portion seems to wear away more rapidly in adults than it grows. Resultantly, B/A shows generally a slight trend towards the increase with age. The surface of the operculum is usually plain, although there are a spiral series of craw-like sculptures in *A. inflata* and a number of dots in *A. turriculata.* The attachment places of foot muscles to the operculum are defined rather clearly in *A. turriculata* and *A. fusca,* both have somewhat thicker operculum. Growth lines on the major part of the operculum are very clear in some specimens, but they may be quite obscure in some others. The distinctness seems to differ individually and evidently this is of no taxonomic significance.

II. Descriptions of opercula of the species that can be identified easily and distinctly by shell characters

1. *Oxygyrus keraudreni* (LESUEUR)

(Text-figs. 2 and 2a)

Very wide; i.e. much elongate in the antero-posterior direction. The axial margin is nearly straight. Gyre is very small and wholly taken in the antero-inner portion of the last whorl. Centre of the gyre very small, situated in the antero-peripheral part of the operculum.

The keel of the shell seems to appear from the stage with 0.98–1 mm diameter. The surface of the shell is furnished wholly with undulating lines, two of which join to build up the keel, while 10–14 lines are distributed on the surface of the apical half of the shell and 9–10 ones on the surface of the other half.

Occurrences:

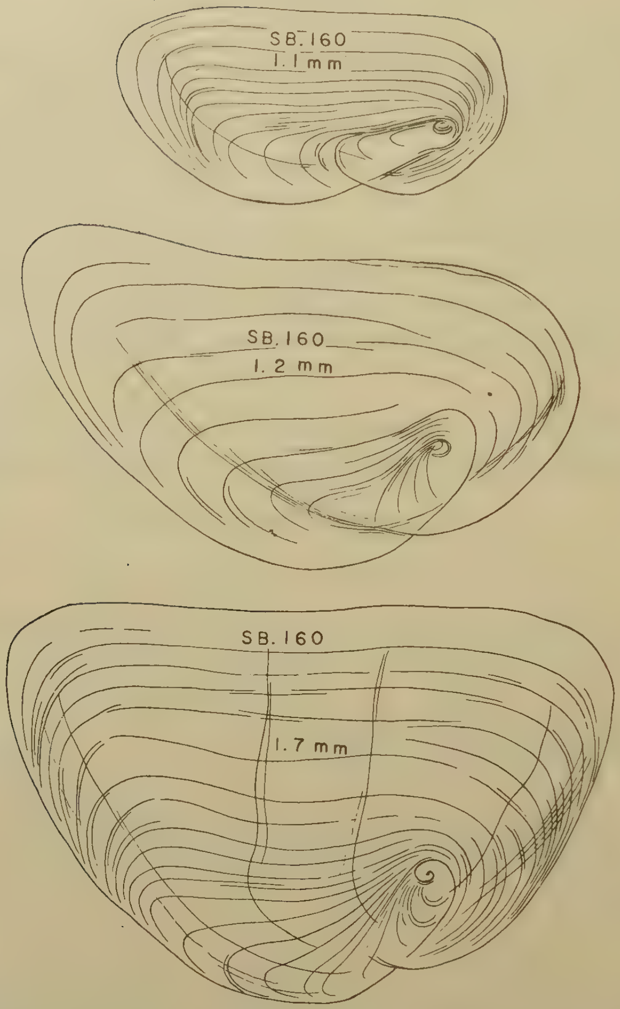
SB 160 (23 shells) SB 187 (3) EQPH 7 (2)
SB 175 (2) SB 200 (3) EQPH 17 (4)

SB···Shellback Stations, EQPH···Horizon Stations during the Equapac Expedition.

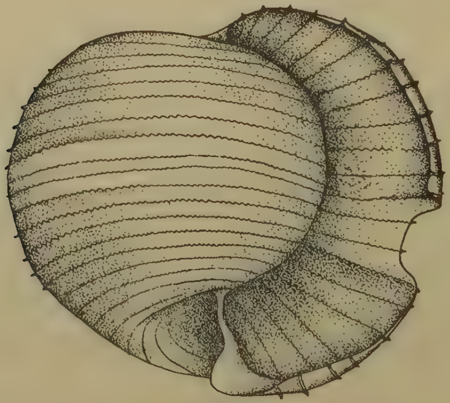
2. *Atlanta turriculata* D'ORBIGNY

(Text-fig. 3)

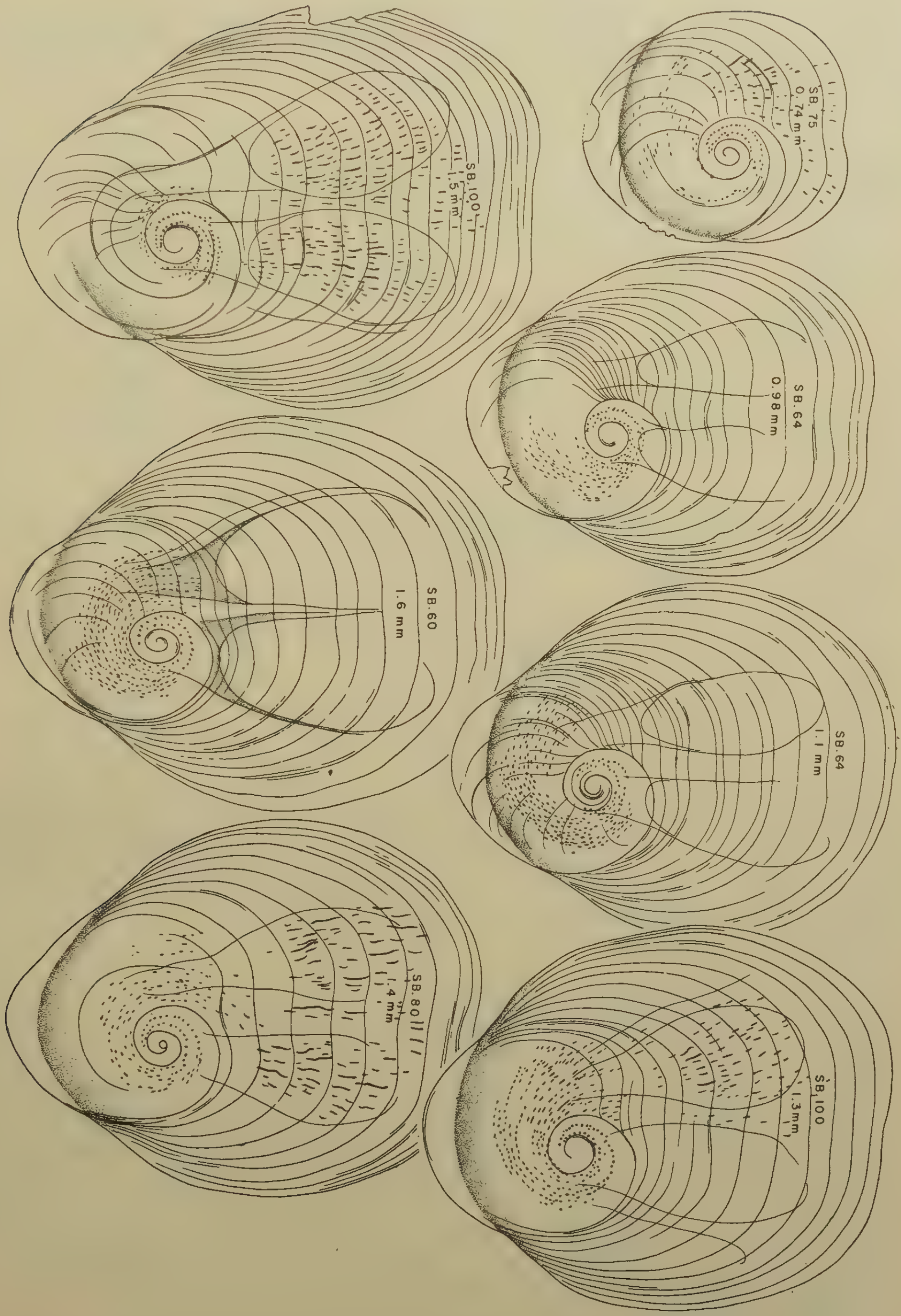
Nearly roundish in outline, W/L very large. The axial margin is rounded, or frequently obtuse. Gyre is comparatively large, but the central portion is rather small and situated in the upper (axial or inner) half of the gyre as is shown by B/A smaller than 0.50, being slightly displaced to the right (anterior) side from the middle as is indicated by D/C ranging from 0.45–0.52. The operculum is pretty thick, but the lower (peripheral) marginal portion of the gyre which is very thin and quite transparent. The gyre is always furnished with a number of dots which are arranged roughly in two rows in the central portion


SB. 160
1.1 mm
SB. 160
1.2 mm
SB. 160
1.7 mm

Text-fig. 2. *Oxygyrus keraudreni* (Lesueur). Opercula of three shells from Shellback Station 160, respectively 1.1, 1.2 and 1.7 mm in diameter: seen from the attachment surface. ×127.



Text-fig. 2a. *Oxygyrus keraudreni* (Lesueur). A young shell with a 0.77 mm long diameter, from SB 160. ×73.


SB.100
1.5 mm
SB.75
0.74 mm
SB.64
0.98 mm
SB.60
1.6 mm
SB.64
1.1 mm
SB.80
1.4 mm
SB.100
1.3mm

Text-fig. 3. *Atlanta turriculata* D'ORBIGNY. Opercula of 0.74~1.6 mm shells from Shellback Stations, seen from the attachment surface. ×86.

of the gyre. Such dots may extend to the major part of the operculum in some specimens, where they become somewhat elongate into dashes. The attachment places of foot muscles are marked very clearly.

Table 1. *A. turriculata* D'ORBIGNY. Whorl formulae.

No. of specimen	Long diameter	Whorl formula	Locality
1	0.74 mm		SB 75
2	1.1	1 : 0.27 : 0.15	SB 80
3	1.2	1 : 0.25 : 0.14	SB 80
4	1.2	1 : 0.24 : 0.15	SB 80
5	1.3	1 : 0.24 : 0.14	SB 80
6	1.3	1 : 0.28 : —	SB 100
7	1.4	1 : 0.28 : 0.14	SB 80
8	1.5	1 : 0.24 : 0.13	SB 80
9	1.5	1 : 0.27 : 0.12	SB 80
10	1.5	1 : 0.25 : —	SB 100

Table 2. A. *turriculata* D'ORBIGNY. Measurements on opercula.

No. of specimen	Long. dia. of shell	L	A	W/L	A/L	B/A	D/C
1	0.74 mm	421 μ	321 μ	0.88	0.76	0.43	0.49
	0.98	647	326	0.80	0.50	0.40	0.48
	1.1	711	332	0.73	0.47	0.44	0.52
6	1.3	758	347	0.81	0.46	0.41	0.45
7	1.4	758	347	0.79	0.46	0.41	0.47
10	1.5	789	326	0.79	0.41	0.42	0.46
	1.6	842	358	0.76	0.43	0.43	0.52

Perfect shells can be identified very easily by the characteristic feature of the spire remarkably heightened and usually coloured in purplish brown. Imperfectly preserved shells, in which the spires are completely torn off, can be identified distinctly by the feature of the operculum.

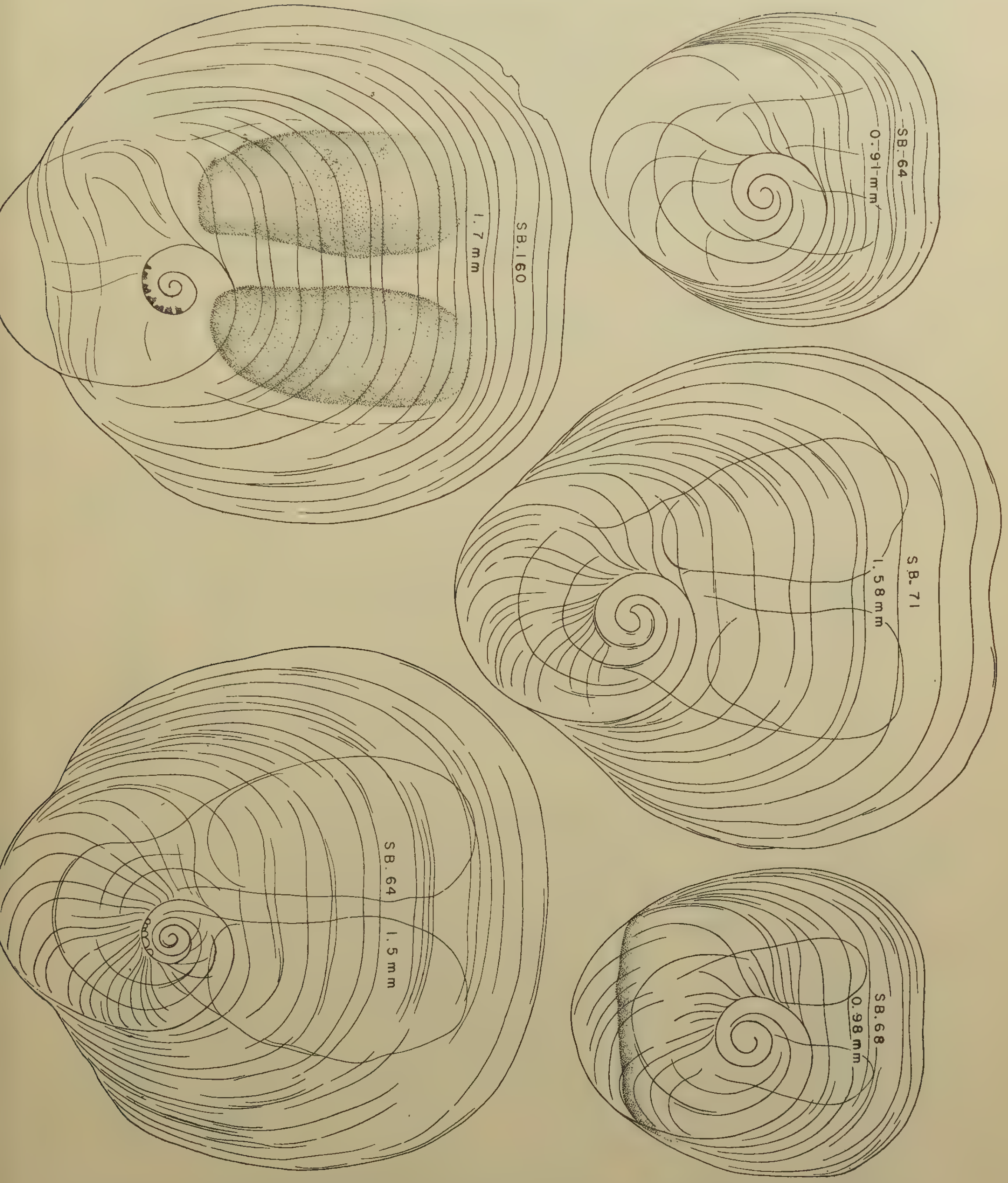
Occurrences:

SB 15 (+)
SB 60 (1)
SB 64 (2)
SB 75 (1)
SB 80 (7)
SB 100 (2)
SB 118 (1)
SB 125 (1)
SB 137 (2)
SB 145 (3)
SB 150 (1)
SB 155 (1)
SB 160 (12)
SB 175 (7)
SB 181 (1)
SB 187 (15)
SB 195 (2)
SB 200 (21)
SB 210 (1)
EQPH 7 (7)
EQPH 11 (2)

3. *Atlanta fusca* SOULEYET

(Text-fig. 4)

Opercula of very young shells are roughly oval, but those of grown ups are much widened, W/L being 0.87–0.96 in examined specimens. The axial margin


SB.160
1.7 mm
SB-64
0·91 mm
S.B.71
1.58 mm
SB.64
1.5 mm
SB.68
0.98 mm

Text-fig. 4. *Atlanta fusca* SOULEYET. Opercula of 0.91~1.7 mm shells from Shellback Stations, seen from the attachment surface. ×107.

is usually obtuse, nearly straight. Gyre is large, but the central portion is comparatively small, situated in the upper axial half and displaced a little from the middle to the anterior side. Very thick throughout. There are several (from 1 to 6) small thickenings in the central portion of the gyre in larger specimens as seen in 1.5 and 1.7 mm shells shown in fig. 4. A pair of traces of pedal muscles are printed very clearly as elongate thinner areas and sometimes marked distinctly by dark pigments remained there.

The general feature of the thick operculum of this species resembles closely that of *A. turriculata*, but it is evidently wider in *fusca* than in *turriculata*.

Table 3. *A. fusca* SOULEYET. Whorl formulae.

No. of specimen	Long diameter	Whorl formula	Number of whorls	Number of whorls on underside	Locality
1	0.89 mm	1 : 0.32 : 0.15			SB 68
2	0.91	1 : 0.36 : 0.21	3-3/4?		SB 64
3	1.5	1 : 0.31 : 0.14	ca. 3?		SB 64
4	1.58	1 : 0.32 : 0.15			SB 71
5	1.7	1 : 0.29 : 0.15	4-1/4	2	SB 160

Table 4. *A. fusca* SOULEYET. Measurements on opercula.

No. of specimen	Long dia. of shell	L	A	W/L	A/L	B/A	D/C
2	0.91 mm	484 μ	337 μ	0.90	0.70	0.41	0.46
	0.98	489	337	0.87	0.69	0.41	0.46
3	1.5	758	337	0.96	0.44	0.38	0.40
4	1.58	768	342	0.91	0.45	0.42	0.46
5	1.7	805	347	0.89	0.43	0.38	0.43

The perfectly preserved specimens of grown up shells of the present species are easily distinguished from others by its characteristic fuscous colouration with a yellowish tint on the whorls and a whitish keel and also by whorl formula with larger middle and last terms. Spire is usually paler in colouration, but never coloured purplish. A pair of dark pigment flecks frequently found at the attachment points of the pedal muscles to the operculum are very helpful for identification, too. The eyes are pale orange, much paler than in other species in preserved state. Juvenile shells resemble those of *A. inclinata* which are also fuscous, but the whorls are more numerous and the spire is higher in *inclinata* than in *fusca*. The differences between juvenile opercula of *fusca* and *inclinata* are given in the descriptions of *inclinata*.

Occurrences:

SB 64 (2)
SB 68 (1)
SB 71 (1)
SB 75 (?1)
SB 80 (1)
SB 137 (1)
SB 160 (1)
SB 175 (?1)
SB 181 (1)

4. *Atlanta lesueuri* Souleyet

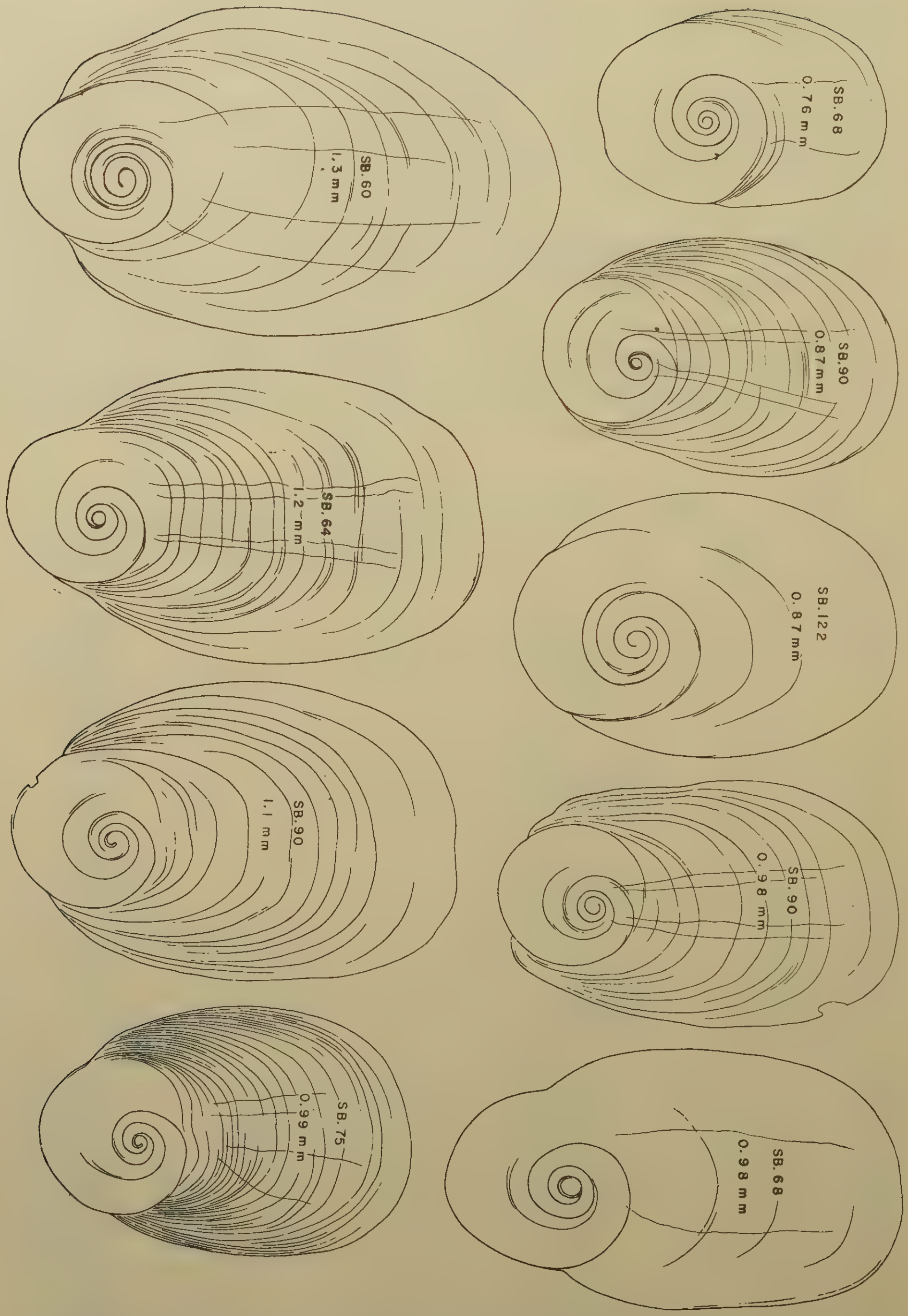
(Text-figs. 5–6)

Elongate oval in outline, W/L being rather small. The axial margin is usually rounded. Gyre relatively small, with rather large central portion located nearly at the centre, the accurate situation is, however, very slightly displaced towards the axial side. The whole operculum is extremely thin.

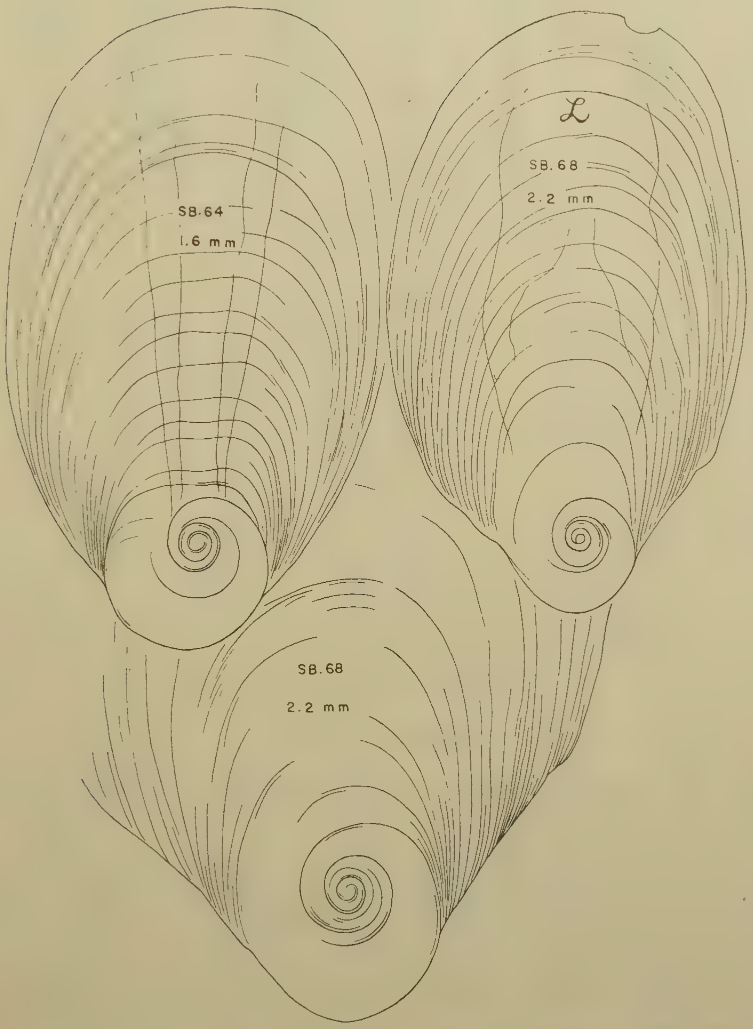
The shells of this species can be easily identified by their unusually large body whorl and by the feature of the spire with much fewer whorls than in any other species. Specimens whose spires are torn off may be identified exactly by the feature of the operculum. Eyes are coloured pale orange to red; of the thirteen examined specimens seven have eyes coloured pale orange, three with reddish orange eyes and other three with red ones.

Table 5. *Atlanta lesueuri* Souleyet. Whorl formulae.

No. of specimen	Long diameter	Whorl formula	Number of whorls	Number of whorls on underside	Locality
1	0.76 mm	1 : 0.29 : —	2–1/2		SB 68
2	0.8	1 : 0.21 : 0.13	3		SB 80
3	0.87	1 : 0.25 : 0.10	2–1/2		SB 90
4	0.87	1 : 0.30 : 0.13	3	1–1/4	SB 122
5	0.9	1 : 0.24 : 0.12	3		SB 80
6	0.91	1 : 0.24 : —			SB 100
7	0.98	1 : 0.22 : 0.09	3		SB 68
8	0.98	1 : 0.22 : 0.11	2–3/4		SB 90
9	0.99	1 : 0.22 : 0.11	2–1/2		SB 75
10	1.00	1 : 0.26 : 0.13	3–		SB 105
11	1.10	1 : 0.23 : 0.13	3		SB 105
12	1.10	1 : 0.23 : 0.12	3		SB 130
13	1.10	1 : 0.22 : 0.10	2–3/4		SB 90
14	1.10	1 : 0.20 : —			SB 100
15	1.10	1 : 0.20 : 0.10	3		SB 80
16	1.2	1 : 0.20 : 0.09	2–3/4		SB 64
17	1.2	1 : 0.26 : 0.13	3–1/4		SB 130
18	1.3	1 : 0.21 : —			SB 100
19	1.3	1 : 0.20 : 0.10	3–1/4		SB 80
20	1.3	1 : 0.20 : 0.10	3	1–1/2	SB 145
21	1.4	1 : 0.25 : 0.12	3–1/2		SB 105
22	1.41	1 : 0.20 : 0.08	3		SB 75
23	1.5	1 : 0.16 : 0.09	3–1/4		SB 80
24	1.6	1 : 0.19 : 0.08	3		SB 64
25	1.6	1 : 0.19 : 0.07	3–1/4		SB 75
26	1.6	1 : 0.19 : 0.08	?3		SB 100
27	1.7	1 : 0.19 : 0.08	2–1/2		SB 100
28	1.7	1 : 0.19 : —			SB 100
29	1.7	1 : 0.20 : 0.09	3–1/4		SB 130
30	1.8	1 : 0.19 : 0.09	3–1/4		SB 130
31	1.9	1 : 0.18 : 0.09	3–1/4		SB 130
32	2.2	1 : 0.16 : 0.07	3–1/2		SB 68
33	2.7	1 : 0.17 : 0.07	3–1/2		SB 130
34	2.9	1 : 0.18 : 0.08			SB 118


SB.60
1.3 mm
SB.68
0.76 mm
SB.90
0.87 mm
SB.64
1.2 mm
SB.122
0.87 mm
SB.90
1.1 mm
SB.90
0.98 mm
SB.75
0.99 mm
SB.68
0.98 mm

Text-fig. 5. *Atlanta lesueuri* Souleyet. Opercula of 0.76~1.3 mm shells from Shellback Stations, seen from the attachment surface. ×93.


SB.64
1.6 mm
L
SB.68
2.2 mm
SB.68
2.2 mm

Text-fig. 6. *Atlanta lesueuri* SOULEYET. Opercula of 1.6 and 2.2 mm shells from Shellback Stations, seen from the attachment surface. L…×55, others…×95.

Table 6. *Atlanta lesueuri* SOULEYET. Measurements on opercula.

No. of specimen	Long dia. of shell	L	A	W/L	A/L	B/A	D/C
1	0.76 mm	426 μ	247 μ	0.68	0.58	0.55	0.68
3	0.87	521	200	0.67	0.38	0.45	0.51
4	0.87	563	274	0.69	0.49	0.56	0.59
7	0.98	668	274	0.57	0.41	0.56	0.67
8	0.98	589	216	0.62	0.37	0.54	0.54
9	0.99	547	221	0.67	0.40	0.50	0.58
13	1.1	653	221	0.68	0.34	0.48	0.53
16	1.2	705	211	0.62	0.30	0.50	0.59
	1.3	800	232	0.61	0.29	0.52	0.58
24	1.6	895	216	0.59	0.24	0.49	0.55
32	2.2	1455	282	0.59	0.19	0.56	0.65

Occurrences:

SB 50 (1)
SB 55 (23)
SB 60 (11)
SB 64 (6)
SB 68 (12)
SB 75 (3)
SB 80 (5)
SB 90 (9)
SB 95 (8)
SB 100 (13)
SB 105 (3)
SB 109 (13)
SB 112 (2)
SB 115 (1)
SB 118 (1)
SB 122 (1)
SB 130 (6)
SB 132 (4)
SB 137 (64)
SB 142 (5)
SB 145 (5)
SB 150 (5)
SB 155 (18)
SB 160 (29)
SB 175 (20)
SB 180 (26)
SB 181 (28)
SB 187 (7)
SB 195 (2)
SB 200 (32)
SB 210 (7)
SB 215 (1)
EQPH 7 (3)
EQPH 11 (19)

5. *Atlanta inclinata* SOULEYET

(Text-figs. 7–10)

Opercula of young shells are nearly roundish to oval and with the axial margin straight or obtuse, while those of grown ups are much elongate and the axial margin is always rounded. Gyre is large and nearly roundish in outline, its central portion is of a moderate size and situated near the middle in the axial half of the gyre. The operculum itself is extremely thin. The structure of gyre resembles somewhat that of *A. fusca*, but in the latter, the operculum is much thicker, W/L is much larger in grown ups and D/C is somewhat smaller than in the present species.

The perfectly preserved shells are easily identified exactly, but the identification of imperfect specimens in which the spires are torn off is rather exact. In such a case, the feature of the operculum, for instance, the size of the gyre and the accurate situation of the central portion shown by B/A and D/C are useful for identification, although some confusions are inevitable between this and some of other species as mentioned later. Eyes were always coloured red in preserved specimens examined.

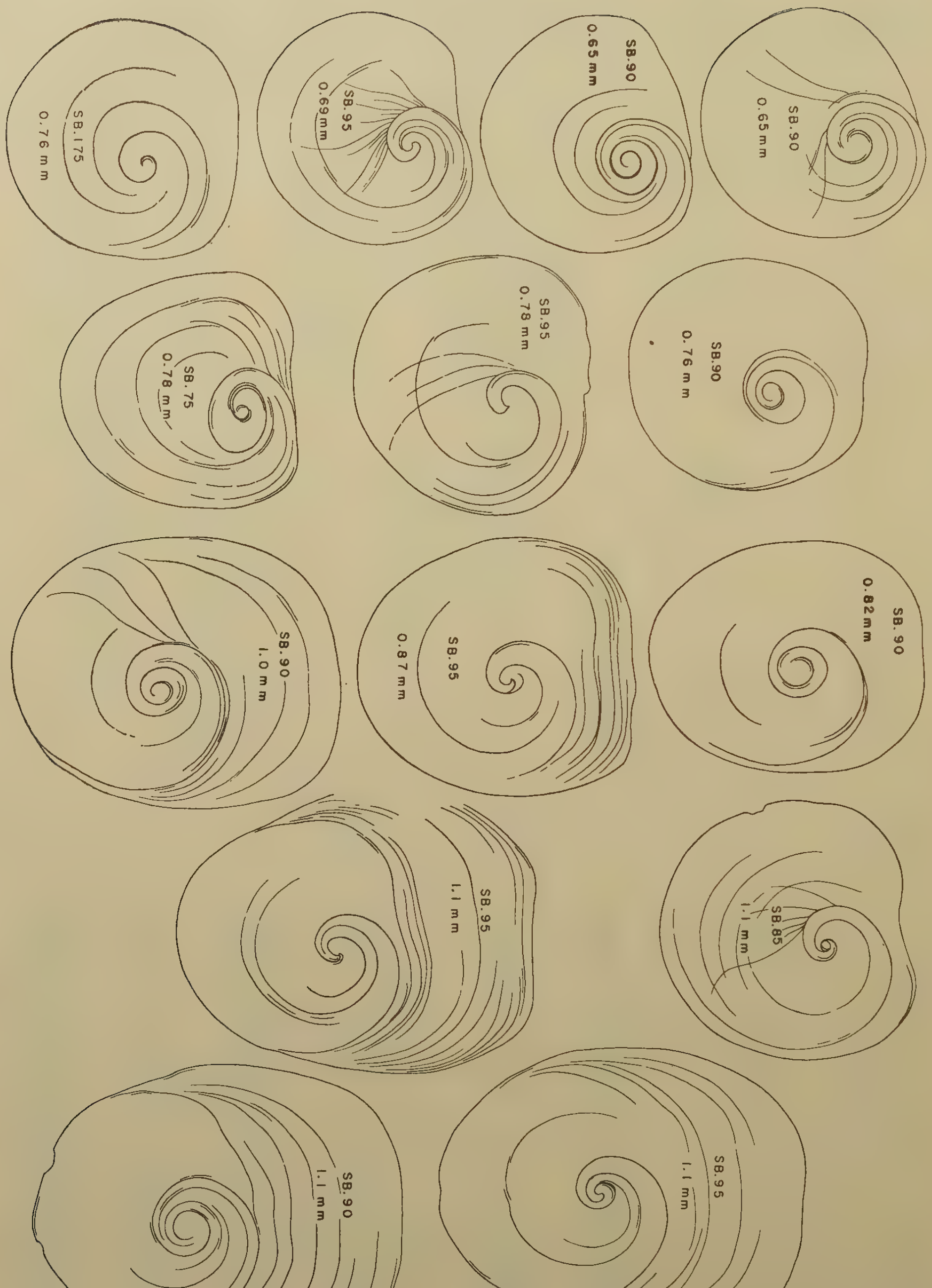
Table 7. *Atlanta inclinata* SOULEYET. Whorl formulae.

No. of specimen	Long diameter	Whorl formula	Number of whorls	Locality
1	0.65 mm	1 : 0.50 : 0.32	3-1/2	SB 90
2	0.65	1 : 0.43 : —		SB 90
3	0.69	1 : 0.56 : —		SB 95
4	0.76	1 : 0.43 : —		SB 90
5	0.76	1 : 0.46 : 0.26	3-1/2	SB 175
6	0.78	1 : 0.53 : —		SB 95
7	0.78	1 : 0.56 : —	4-3/4	SB 75
8	0.82	1 : 0.45 : 0.26		SB 90
9	0.82	1 : 0.39 : —		SB 90
10	0.87	1 : 0.50 : —		SB 95
12	1.00	1 : 0.39 : 0.22	4	SB 90
13	1.1	1 : 0.41 : 0.27	5	SB 85
14	1.1	1 : 0.35 : 0.19	4	SB 90
15	1.1	1 : 0.38 : —		SB 95
16	1.1	1 : 0.40 : —		SB 95
17	1.1	1 : 0.40 : —	5	SB 95
18	1.3	1 : 0.34 : —		SB 90
19	1.3	1 : 0.37 : —		SB 95
20	1.6	1 : 0.34 : 0.19	4-1/2	SB 90
21	1.7	1 : 0.34 : —		SB 90
22	1.7	1 : 0.35 : 0.25	5-1/2*	SB 118
23	2.0	1 : 0.31 : 0.19	5-1/4	SB 80
24	2.0	1 : 0.31 : 0.19		SB 85
25	2.2			SB 175
26	2.4	1 : 0.27 : —		SB 90
27	3.4	1 : 0.28 : 0.13	5+	SB 95
28	3.4			SB 115

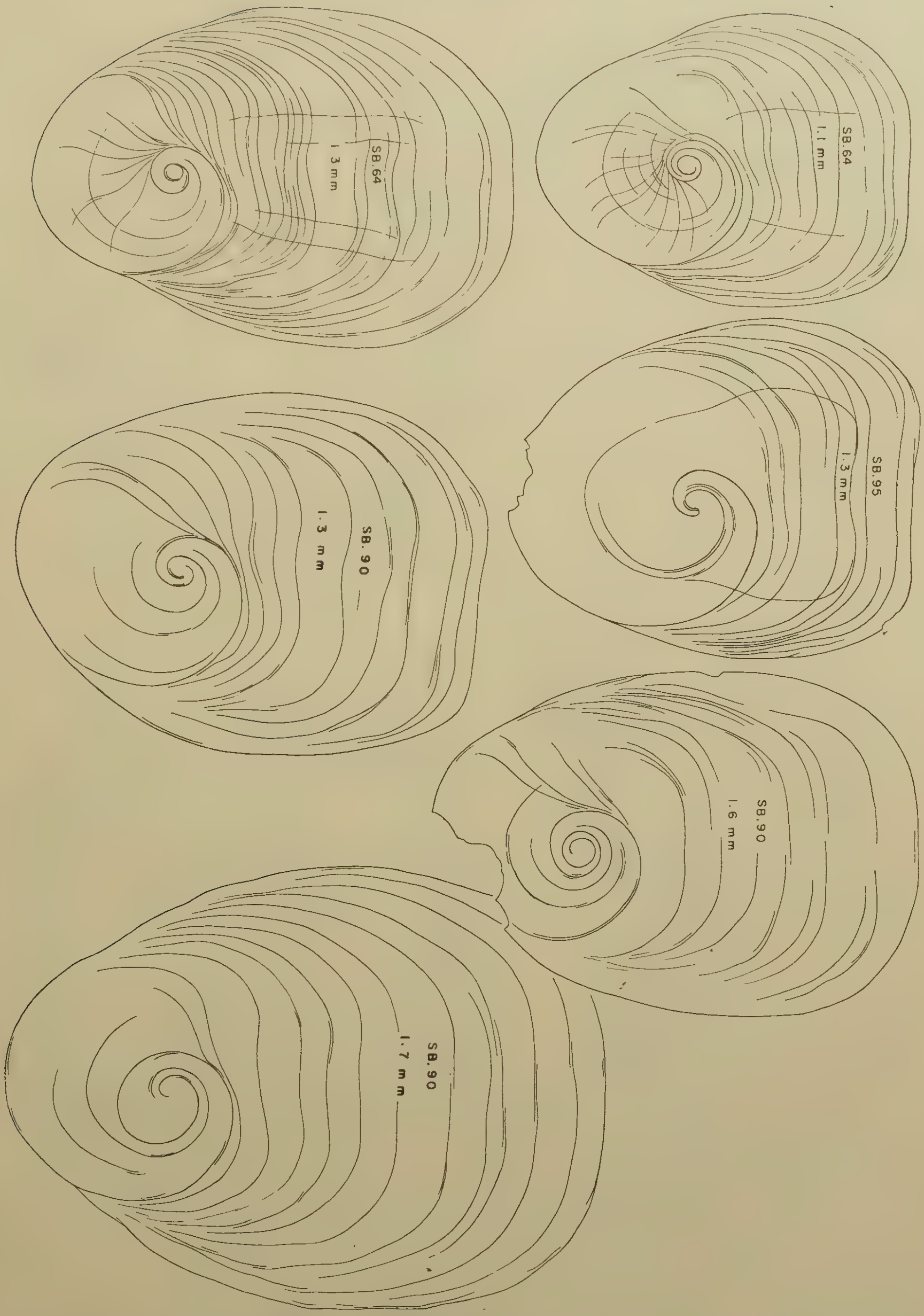
* ca. 2 whorls on the underside.

Table 8. *Atlanta inclinata* SOULEYET. Measurements on opercula.

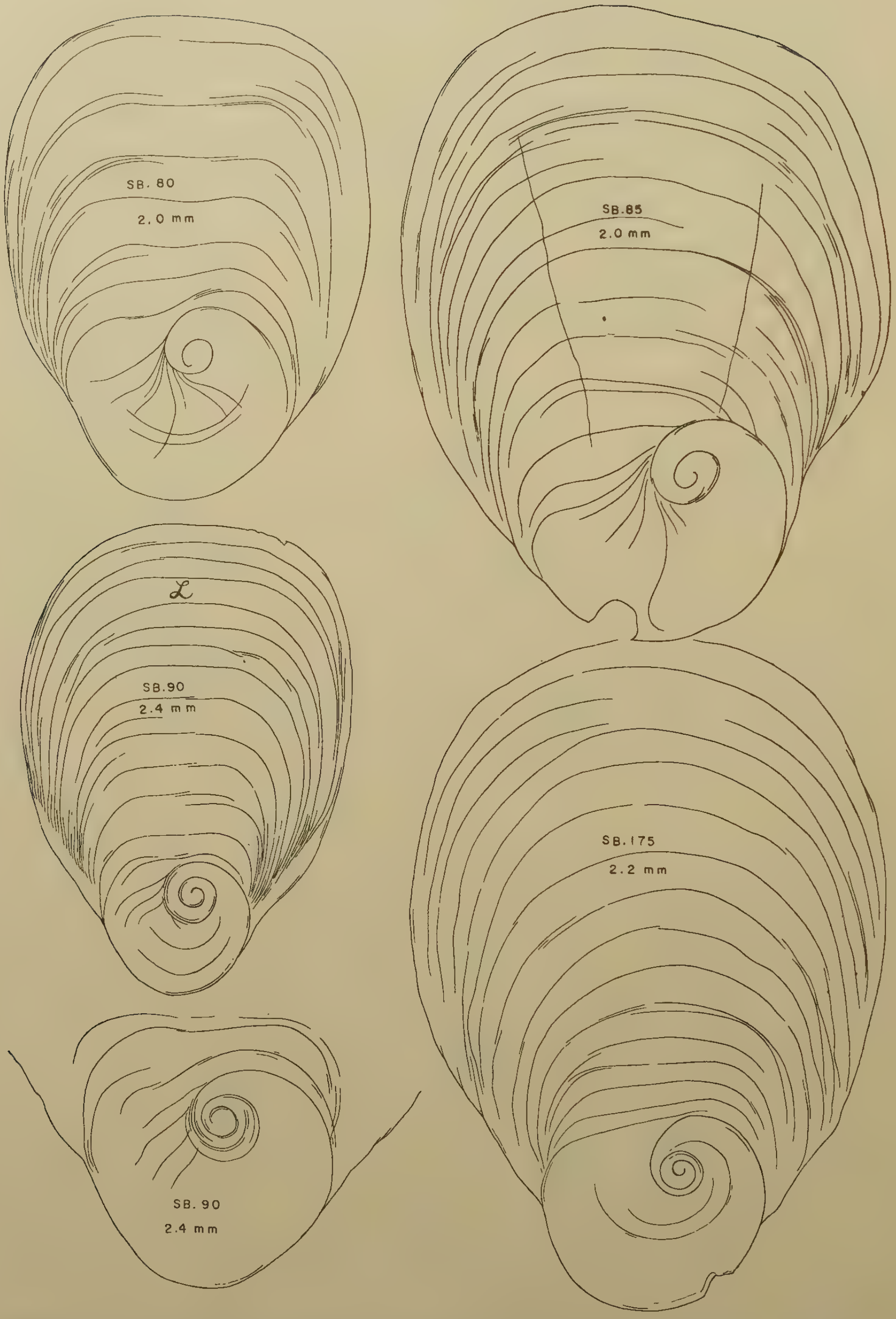
No. of specimen	Long dia. of shell	L	A	W/L	A/L	B/A	D/C
1	0.65 mm	353 μ	353 μ	0.99	1.00	0.43	0.55
2	0.65	337	337	1.08	1.00	0.45	0.51
3	0.69	337	337	1.05	1.00	0.39	0.51
4	0.76	358	316	0.99	0.88	0.42	0.48
5	0.76	358	321	1.00	0.90	0.43	0.48
6	0.78	363	321	1.09	0.88	0.36	0.43
7	0.78	368	368	0.97	1.00	0.37	0.49
8	0.82	416	332	0.85	0.80	0.44	0.53
10	0.87	421	332	0.94	0.79	0.40	0.49
12	1.0	500	332	0.83	0.66	0.46	0.51
13	1.1	384	347	1.03	0.90	0.38	0.46
14	1.1	563	347	0.79	0.62	0.47	0.54
15	1.1	542	337	0.81	0.62	0.36	0.47
16	1.1	553	342	0.80	0.62	0.38	0.52
	1.1	584	316	0.78	0.54	0.38	0.52
	1.3	742	295	0.70	0.40	0.36	0.46
18	1.3	716	363	0.79	0.51	0.39	0.48
19	1.3	632	384	0.84	0.61	0.32	0.48
20	1.6	758	332	0.71	0.44	0.43	0.50
21	1.7	926	358	0.74	0.39	0.49	0.52
23	2.0	768	311	0.75	0.40	0.34	0.47
24	2.0	1010	358	0.76	0.35	0.38	0.43
25	2.2	1060	305	0.70	0.29	0.41	0.48
26	2.4	1290	373	0.70	0.29	0.42	0.51
27	3.4	1710	364	0.64	0.21	0.40	0.52
28	3.4	1460	416	0.67	0.29	0.37	0.46


SB.175
0.76 mm
SB.95
0.69mm
SB.90
0.65mm
SB.90
0.65mm
SB.75
0.78 mm
SB.95
0.78 mm
SB.90
0.76 mm
SB.90
1.0 mm
SB.95
0.87 mm
SB.90
0.82mm
SB.95
1.1 mm
SB.85
1.1 mm
SB.90
1.1 mm
SB.95
1.1 mm

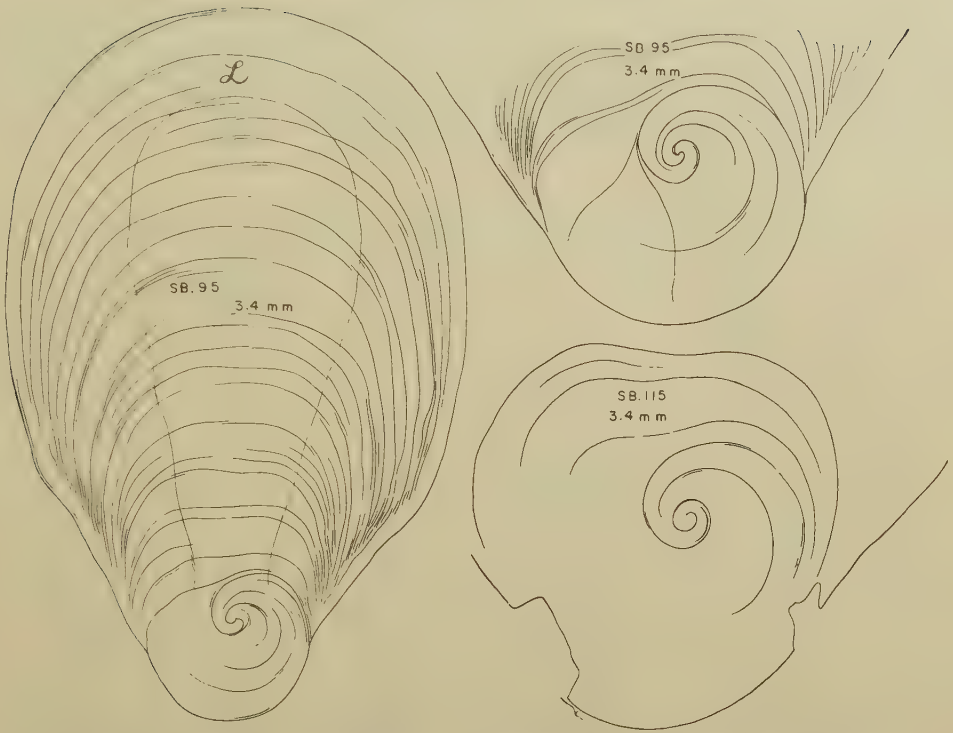
Text-fig. 7. *Atlanta inclinata* Souleyet. Opercula of 0.65∼1.1 mm shells from Shellback Stations, seen from the attachment surface. ×86.


SB.64
1.3 mm
SB.64
1.1 mm
SB. 90
1.3 mm
SB.95
1.3 mm
SB.90
1.6 mm
SB.90
1.7 mm

Text-fig. 8. *Atlanta inclinata* SOULEYET. Opercula of 1.1~1.7 mm shells from Shellback Stations, seen from the attachment surface. ×86.


SB. 80
2.0 mm
SB.85
2.0 mm
ℒ
SB.90
2.4 mm
SB.175
2.2 mm
SB. 90
2.4 mm

Text-fig. 9. *Atlanta inclinata* SOULEYET. Opercula of 2.0~2.4 mm shells from Shellback Stations, seen from the attachment surface. L···×50, others···×85.



Text-fig. 10. *Atlanta inclinata* SOULEYET. Opercula of 3.4 mm shells from Shellback Stations, seen from the attachment surface. L···×55, others···×95.

Occurrences:

SB 55 (10)
SB 60 (2)
SB 64 (2)
SB 75 (2)
SB 80 (2)
SB 85 (2)
SB 90 (12)
SB 95 (8)
SB 115 (8)
SB 118 (5)
SB 137 (2)
SB 145 (1)
SB 150 (3)
SB 155 (2)
SB 160 (11)
SB 175 (15)
SB 180 (8)
SB 181 (8)
SB 187 (6)
SB 195 (3)
SB 200 (8)
SB 210 (1)
EQPH 3 (2)
EQPH 7 (4)
EQPH 11 (6)
EQPH 17 (12)
EQPS 28 (1)

EQPS···Stranger Station during the Equapac Expedition.

III. Description of the operculum, by which the species can be identified distinctly.

6. *Atlanta inflata* SOULEYET

(Text-figs. 11–12)

There was found a series of opercula which were distinguished very distinctly from others by possessing a row of craw-like sculptures around the central portion of the gyre. Whorl formulae of the shells having such an operculum are given on Table 9 and they conform well to those of *A. inflata* shown in my previous papers (1955 a and b). Very probably, these shells may be identified safely as *A. inflata.*

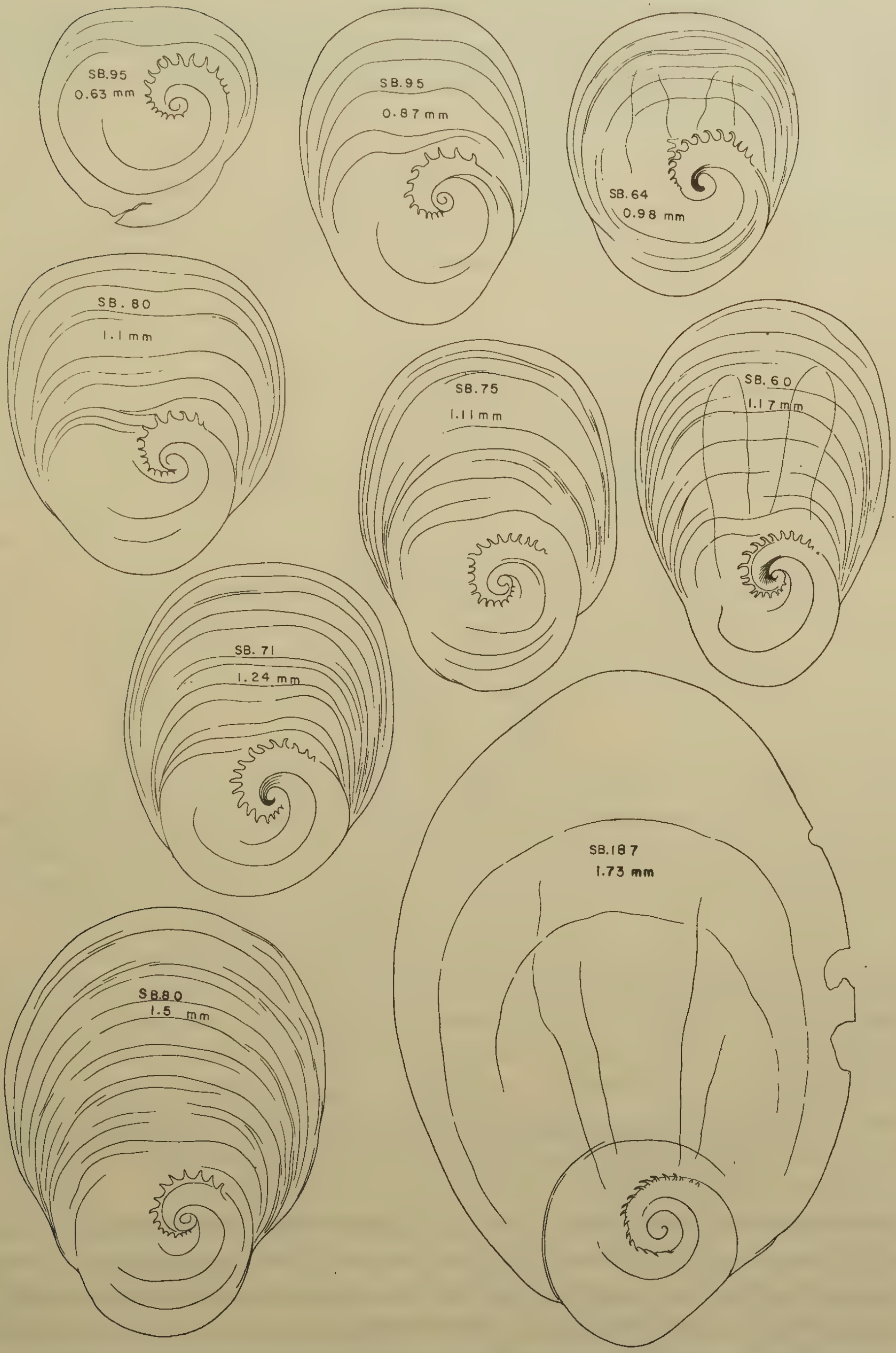
Table 9. *Atlanta inflata* SOULEYET. Whorl formulae.

No. of specimen	Long diameter	Whorl formula	Number of whorls	Number of whorls on underside	Locality
1	0.63 mm	1 : 0.45 : —	?		SB 95
2	0.87	1 : 0.33 : 0.20	4		SB 95
3	0.89	1 : 0.34 : 0.22	4+		SB 160
4	0.98	1 : 0.27 : 0.20	4–1/2		SB 55
5	0.98	1 : 0.33 : 0.20	3–3/4		SB 64
6	1.08	1 : 0.28 : 0.16	4–1/2		SB 60
7	1.1	1 : 0.30 : 0.18	5		SB 55
8	1.1	1 : 0.29 : 0.19	4–1/4		SB 80
9	1.11	1 : 0.29 : 0.18	4		SB 75
10	1.17	1 : 0.30 : 0.18	4–1/2		SB 60
11	1.24	1 : 0.33 : 0.18	4–1/4	2	SB 71
12	1.3	1 : 0.31 : 0.19	4–1/4		SB 160
13	1.3	1 : 0.31 : 0.18	4–1/4		SB 160
14	1.3	1 : 0.30 : 0.17	4–1/4	2–1/4	SB 160
15	1.3	1 : 0.30 : 0.17	4–1/4	2	SB 160
16	1.3	1 : 0.26 : 0.16	4–1/4	2–1/4	SB 160
17	1.4	1 : 0.29 : 0.15	4–1/4		SB 55
18	1.5	1 : 0.31 : 0.16	4–3/4		SB 80
19	1.5	1 : 0.33 : 0.17	4–1/2	2–1/4	SB 80
20	1.5	1 : 0.29 : 0.17	ca. 4	2–1/4	SB 145
21	1.73	1 : 0.28 : 0.11	4–1/4	2–1/4	SB 187
22	1.95	1 : 0.29 : 0.11	5	2–1/4	EQPS 28
23	2.00				SB 180
24	2.6	1 : 0.28 : —	?	2–1/4	SB 155

Table 10. *Atlanta inflata* SOULEYET. Measurements on opercula.

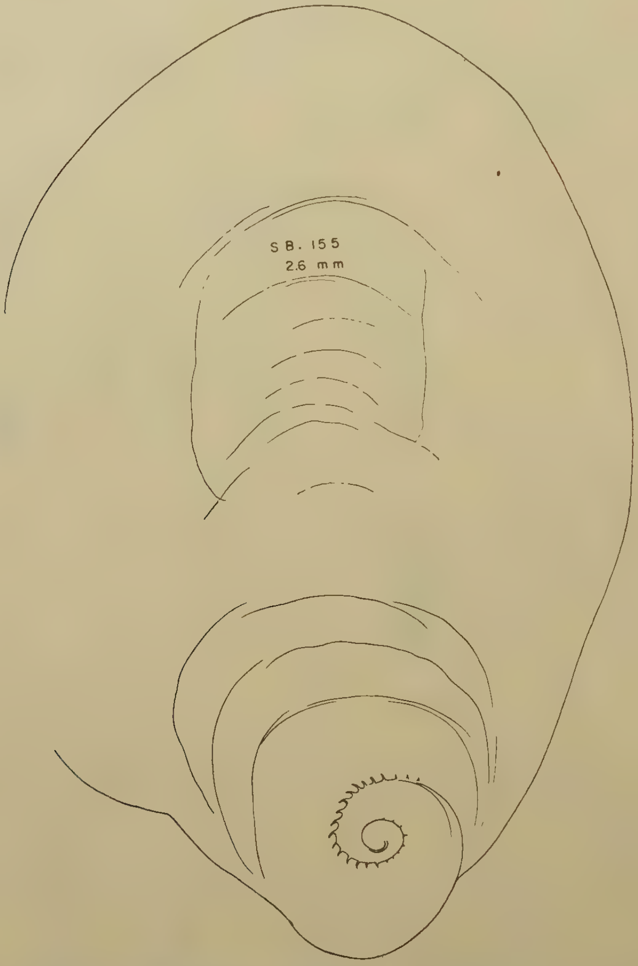
No. of specimen	Long dia. of shell	L	A	W/L	A/L	B/A	D/C
1	0.63 mm	332 μ	247 μ	0.98	0.75	0.32	0.41
2	0.87	479	253	0.73	0.53	0.35	0.48
5	0.98	432	242	0.82	0.56	0.40	0.45
8	1.10	489	237	0.85	0.48	0.34	0.39
9	1.11	537	226	0.73	0.42	0.41	0.56
10	1.17	589	226	0.66	0.38	0.37	0.53
11	1.24	511	226	0.79	0.44	0.47	0.48
18	1.5	653	237	0.74	0.36	0.36	0.49
21	1.73	1031	263	0.68	0.25	0.45	0.50
24	2.6	1321	247	0.68	0.19	0.46	0.54

Operculum is roundish to oval in young shells, but oval in grown ups. The axial margin is usually roundish, excepting the shells of very young stages. Gyre is not so large, A being always less than 270 μ; the central portion is of a moderate size and furnished with 13–26 craw-like sculptures along the suture


SB.95
0.63 mm
SB.95
0.87 mm
SB.64
0.98 mm
SB.80
1.1 mm
SB.75
1.11 mm
SB.60
1.17 mm
SB.71
1.24 mm
SB.187
1.73 mm
SB.80
1.5 mm

Text-fig. 11. *Atlanta inflata* SOULEYET. Opercula of 0.63~1.73 mm shells from Shellback Stations, seen from the attachment surface. ×86.

between it and the last whorl. The central portion is situated wholly in the axial half of the gyre, but near the middle of the antero-posterior axis. The operculum itself is rather thick, especially at the central portion of the gyre where it is somewhat horny.



Text-fig. 12. *Atlanta inflata* SOULEYET. Operculum of a 2.6 mm shell from Shellback Station 155. ×95.

Although the whorl formula of this species differs from those of *A. peroni* and *A. gaudichaudi*, it is rather exact to separate these three species definitely from one another, especially this is the case when young shells are treated or the sculptures on the shell surface are wholly disappeared. The characteristic feature of the operculum, however, makes the identification very easy and distinct.

Throughout the whole specimens identified definitely by using the operculum, the characteristics of the shell of *A. inflata* are shown by whorl formulae given on Table 9; the formulae are characteristic in that the penultimate whorl looks rather wider than in other species; C/A seems to decrease abruptly between Nos. 20 and 21 (1.5 and 1.73 mm specimens shown on the same table). The spire is relatively tall, but this is not always the case, for it may be rather low as in No. 20 specimen. It is usually purplish, and this colouration may extend over the whole shell in a deep tone as in No. 17 specimen. The base of the keel is brownish. Eyes are pale orange in preserved specimens.

Occurrences:

SB 55 (3)
SB 60 (2)
SB 64 (1)
SB 71 (1)
SB 80 (3)
SB 95 (2)
SB 145 (1)
SB 155 (1)
SB 160 (7)
SB 175 (3)
SB 180 (1)
SB 181 (1)
SB 187 (1)
SB 195 (1)
SB 200 (15)
SB 210 (2)
EQPH 11 (17)
EQPS 28 (1)

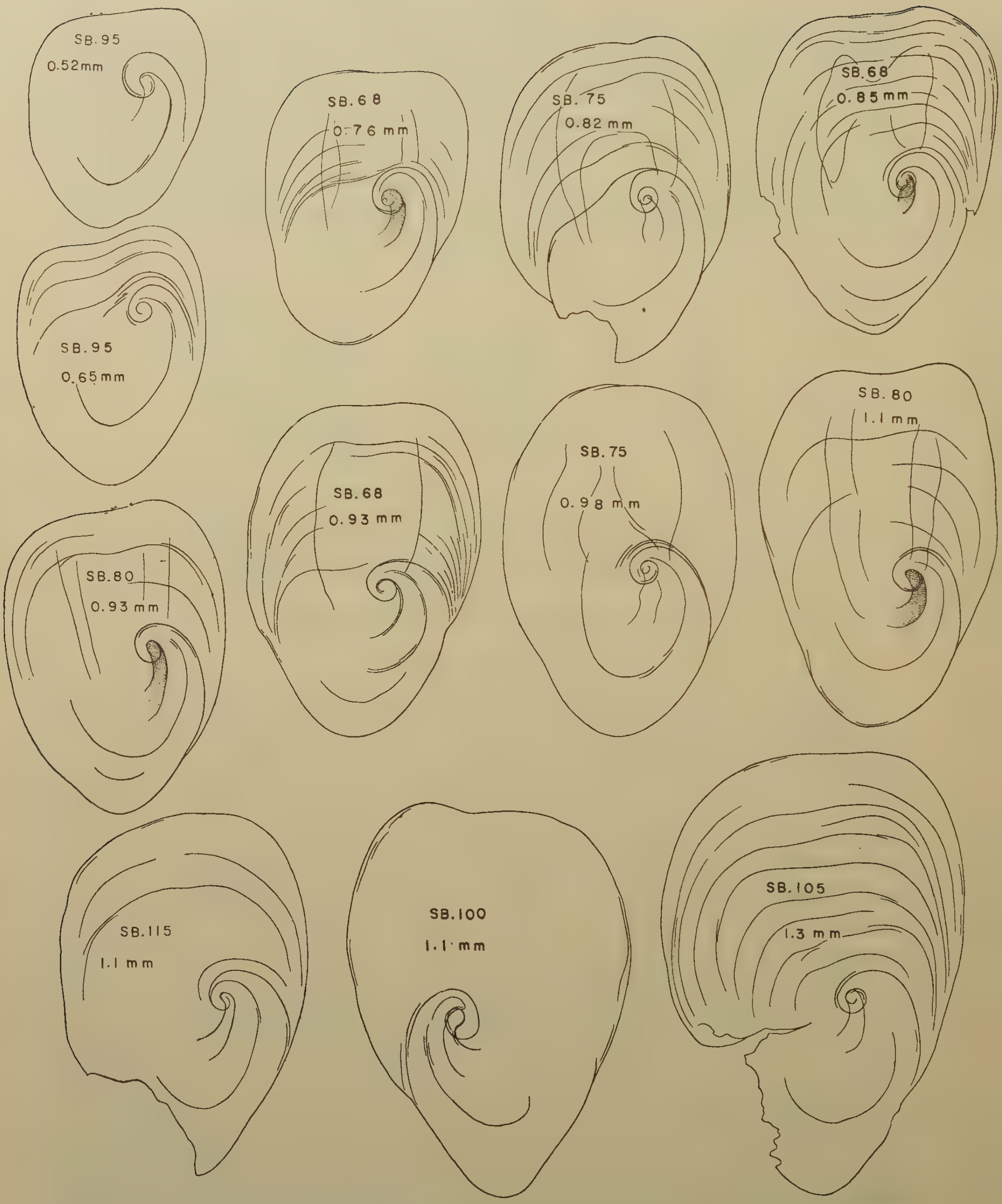
IV. Descriptions of opercula of the species, shells of which resemble one another rather closely.

7. *Atlanta gaudichaudi* SOULEYET

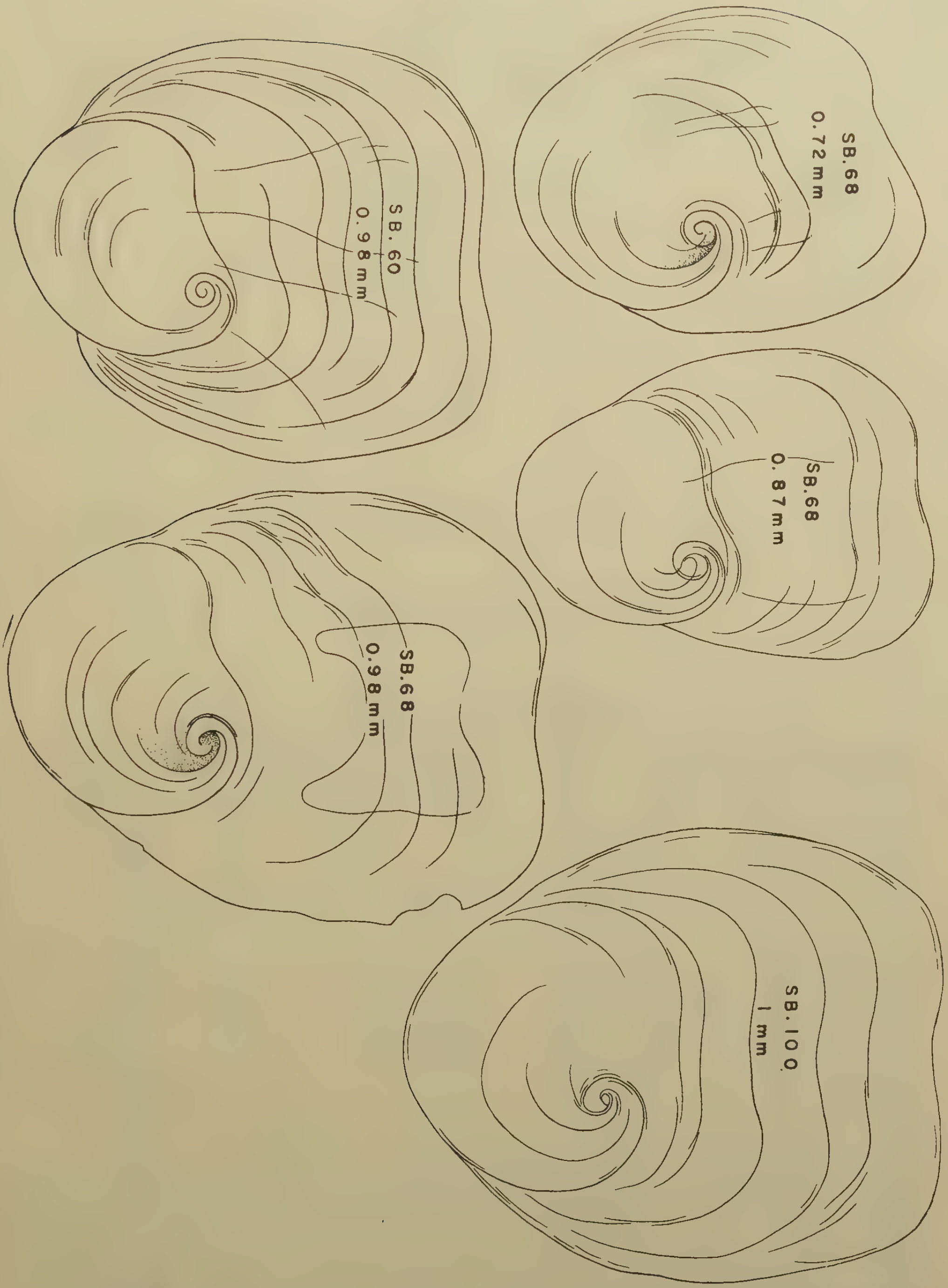
(Text-figs. 13–24)

There are two series of opercula which have each a relatively narrow gyre with the very small central portion situated near its anteroaxial corner. One of them, Series N, consists of opercula having the gyre 242–311μ in length and smaller B/A and D/C, while opercula of the other series, Series W, have the 295–418μ long gyre and larger B/A and D/C.

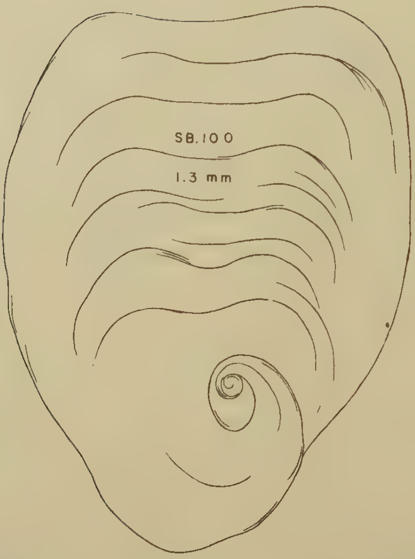
Series N: Opercula of this series were found only in young shells smaller than 1.3 mm in diameter. The typical ones are shown in Text-fig. 13. They are rather elongate, the axial margin in usually truncate and the peripheral end is most frequently acute bluntly. Gyre is short and narrow, the central portion extremely small and situated approximately at the level of the upper (axial) one-fourth and very near the right (anterior) margin. The operculum itself is very thin. Opercula shown in Text-figs. 14–15 are slightly larger than those of Text-fig. 13 and comparatively wider. Gyre is short but rather wide and the lower (peripheral) end is rounded. In spite of the existence of such differences between these and those shown in Text-fig. 13, both opercula seem to be continuous to each other as the close resemblance is shown between the 0.93 mm long specimen from SB 68 (fig. 13) and the 0.87 mm long specimen from SB 68 (fig. 14). Very probably the characteristic feature of the opercula shown in figs. 14–15 is caused by a slight inclination of the axis of the gyre towards the anterior side.


SB.95
0.52mm
SB.68
0.76 mm
SB.75
0.82 mm
SB.68
0.85 mm
SB.95
0.65mm
SB.68
0.93 mm
SB.75
0.98 mm
SB.80
1.1 mm
SB.80
0.93 mm
SB.115
1.1 mm
SB.100
1.1 mm
SB.105
1.3 mm

Text-fig. 13. *Atlanta gaudichaudi* SOULEYET, narrow type. Opercula of 0.52~1.3 mm shells from Shellback Stations, seen from the attachment surface, excepting the 1.1 mm shell from SB 100. ×107.


SB. 60
0.98 mm
SB.68
0.72 mm
SB.68
0.87 mm
SB.68
0.98 mm
SB.100
1 mm

Text-fig. 14. *Atlanta gaudichaudi* Souleyet, narrow type. Opercula of 0.72∼1 mm shells from Shellback Stations, seen from the attachment surface. ×127.



Text-fig. 15. *Altanta gaudichaudi* SOULEYET, narrow type. Operculum of 1.3 mm shell from Shellback Station 100. ×95.

Table 11. *Atlanta gaudichaudi* SOULEYET, Series N. Whorl formulae.

No. of specimen	Long diameter	Whorl formula	Number of whorls	Number of whorls on underside	Locality
1	0.52 mm	1 : 0.46 : —	?		SB 95
2	0.61	1 : 0.39 : —			SB 100
3	0.65	1 : 0.40 : 0.23	4		SB 95
4	0.72	1 : 0.39 : 0.18	3-1/2		SB 68
5	0.76	1 : 0.34 : 0.20	3-1/4		SB 68
6	0.78	1 : 0.36 : 0.22			SB 100
7	0.82	1 : 0.34 : 0.21	3-1/2		SB 75
8	0.85	1 : 0.28 : 0.18	3-1/2		SB 68
9	0.87	1 : 0.32 : 0.20	4-1/2		SB 100
10	0.87	1 : 0.35 : 0.20	4-1/2		SB 100
11	0.87	1 : 0.30 : 0.18	3-3/4		SB 68
12	0.87	1 : 0.35 : 0.22	4-1/2		SB 95
13	0.91	1 : 0.36 : 0.19	4	1-3/4	SB 145
14	0.91	1 : 0.36 : 0.22	4-1/4		SB 60
15	0.91	1 : 0.33 : —			SB 90
16	0.93	1 : 0.35 : 0.21	4-3/4	1-3/4	SB 80
17	0.93	1 : 0.28 : 0.17	3-3/4		SB 68
18	0.93	1 : 0.33 : 0.21	4-3/4		SB 95
19	0.93	1 : 0.35 : 0.21	5		SB 95
20	0.95	1 : 0.32 : 0.18	4-1/2		SB 100
21	0.98	1 : 0.31 : 0.18	4-1/2		SB 100
22	0.98	1 : 0.31 : 0.20	4-1/2		SB 100
23	0.98	1 : 0.31 : 0.18	4-1/4		SB 160
24	0.98	1 : 0.31 : 0.18	4		SB 75
25	0.98	1 : 0.33 : 0.21	4-1/2		SB 60

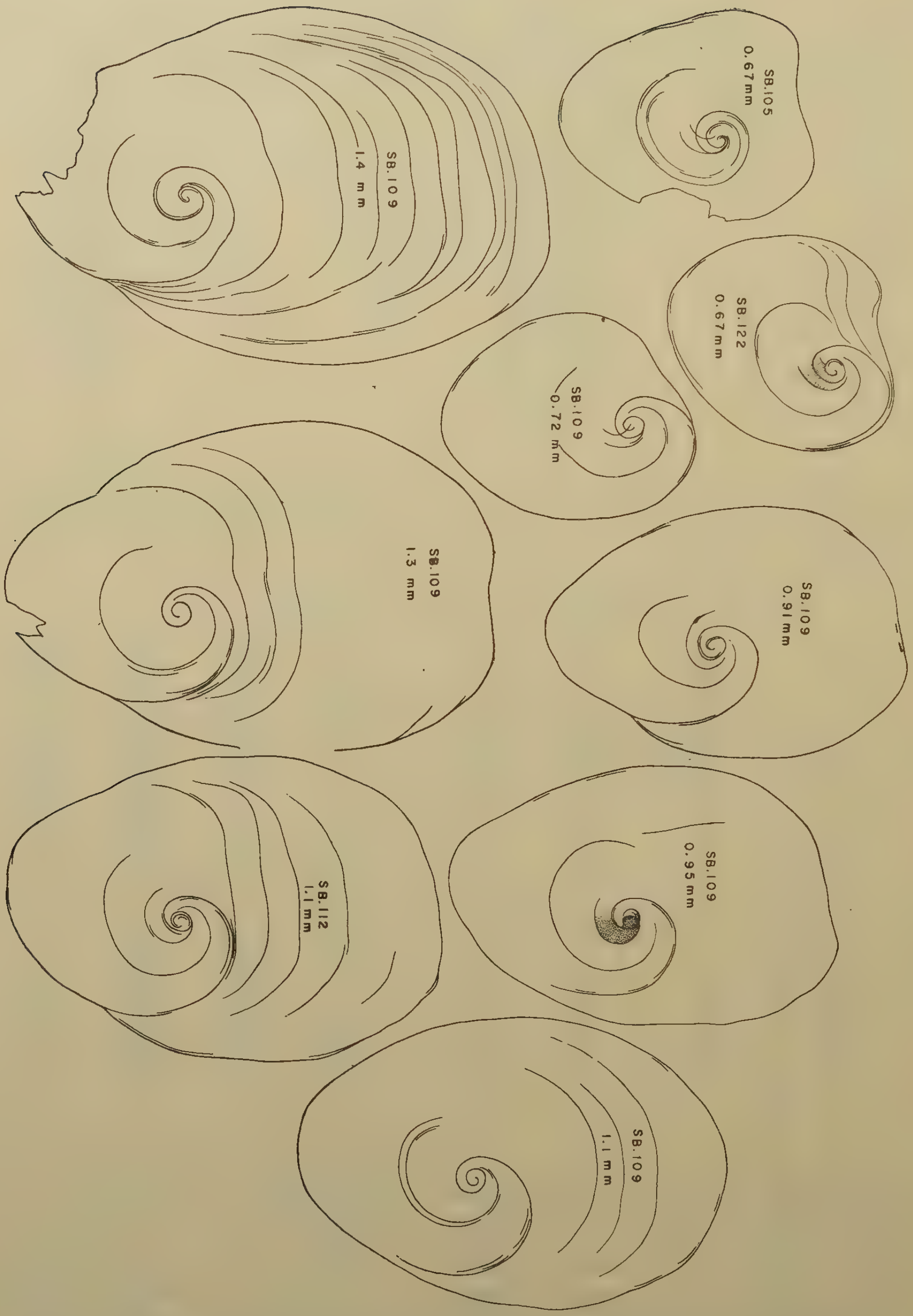
Table 11. (Continued)

No. of specimen	Long diameter	Whorl formula	Number of whorls	Number of whorls on underside	Locality
26	0.98	1 : 0.33 : 0.20	3+		SB 68
27	1.00	1 : 0.34 : 0.21	5		SB 100
28	1.00	1 : 0.33 : 0.22	4+		SB 90
29	1.1	1 : 0.28 : 0.19	4-1/4		SB 90
30	1.1	1 : 0.30 : 0.16	4-1/2		SB 100
31	1.1	1 : 0.34 : 0.20	5		SB 115
32	1.1	1 : 0.31 : 0.19	5+	1-1/2	SB 145
33	1.1	1 : 0.31 : 0.18	4-3/4	1-3/4	SB 80
34	1.2	1 : 0.29 : 0.18	5+	1-1/2	SB 145
35	1.2	1 : 0.39 : 0.21	4?		SB 145
36	1.2	1 : 0.33 : 0.20	5		SB 80
37	1.3	1 : 0.30 : 0.17	5		SB 105
38	1.3	1 : 0.28 : 0.17	4-3/4		SB 100

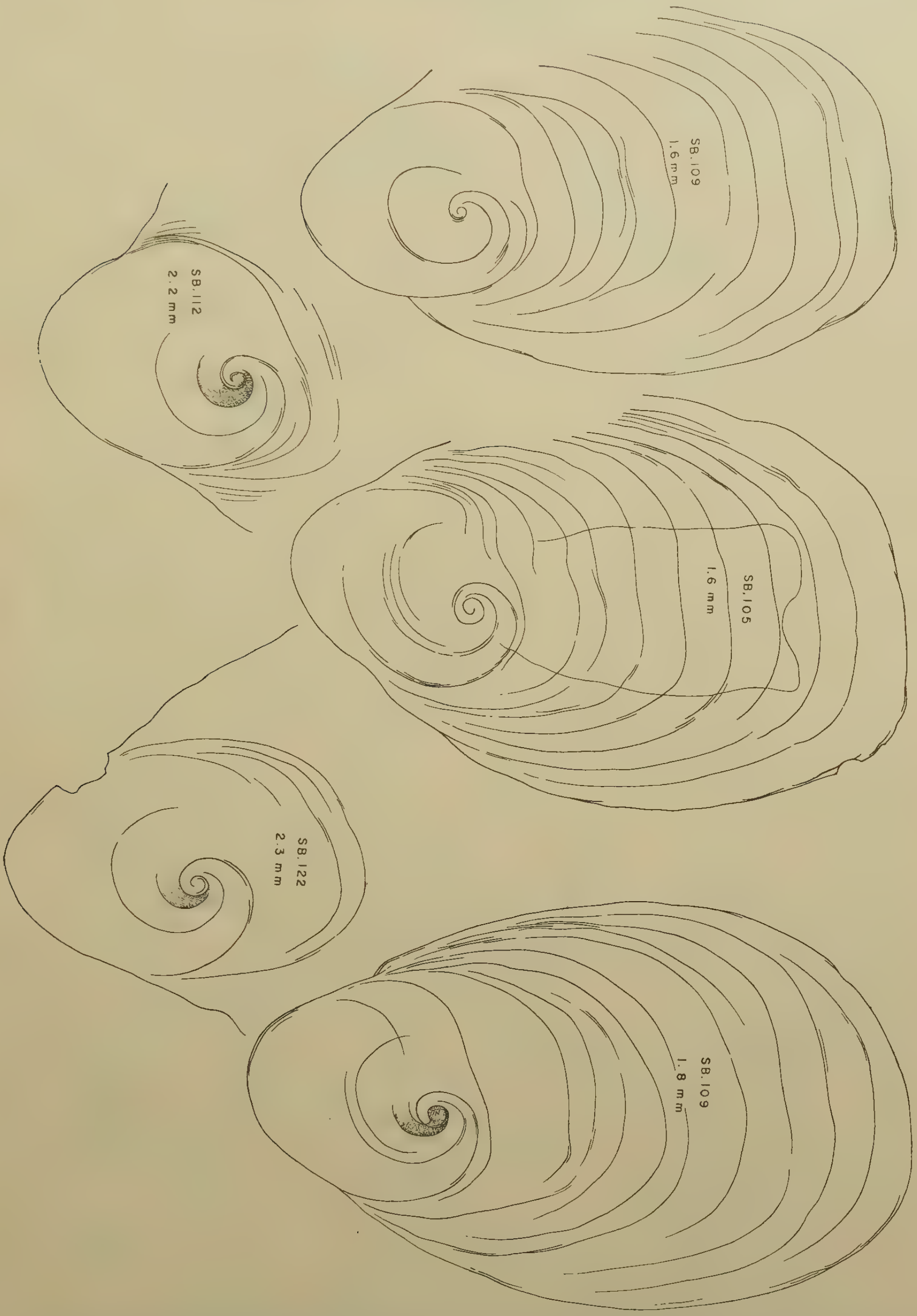
Table 12. *Atlanta gaudichaudi* Souleyet, Series N. Measurements on opercula.

No. of specimen	Long dia. of shell	L	A	W/L	A/L	B/A	D/C
Opercula shown in text-fig. 13.							
1	0.52 mm	311 μ	253 μ	0.78	0.81	0.25	0.35
3	0.65	358	279	0.74	0.78	0.19	0.30
5	0.76	379	258	0.72	0.68	0.27	0.34
7	0.82	437	268	0.72	0.61	0.22	0.29
8	0.85	437	258	0.73	0.59	0.27	0.34
16	0.93	437	268	0.70	0.61	0.20	0.28
17	0.93	458	247	0.70	0.54	0.22	0.33
24	0.98	479	263	0.67	0.55	0.20	0.30
30	1.1	484	253	0.66	0.52	0.23	0.29
31	1.1	500	284	0.68	0.57	0.20	0.28
33	1.1	553	295	0.70	0.53	0.25	0.33
37	1.3	600	311	0.68	0.52	0.19	0.32
Opercula shown in text-figs. 14 and 15.							
4	0.72	453	247	0.79	0.55	0.21	0.27
11	0.87	463	242	0.74	0.52	0.24	0.30
25	0.98	542	258	0.85	0.48	0.22	0.23
26	0.98	589	268	0.80	0.46	0.22	0.27
27	1.00	605	279	0.83	0.46	0.25	0.29
38	1.3	758	289	0.74	0.38	0.35	0.33

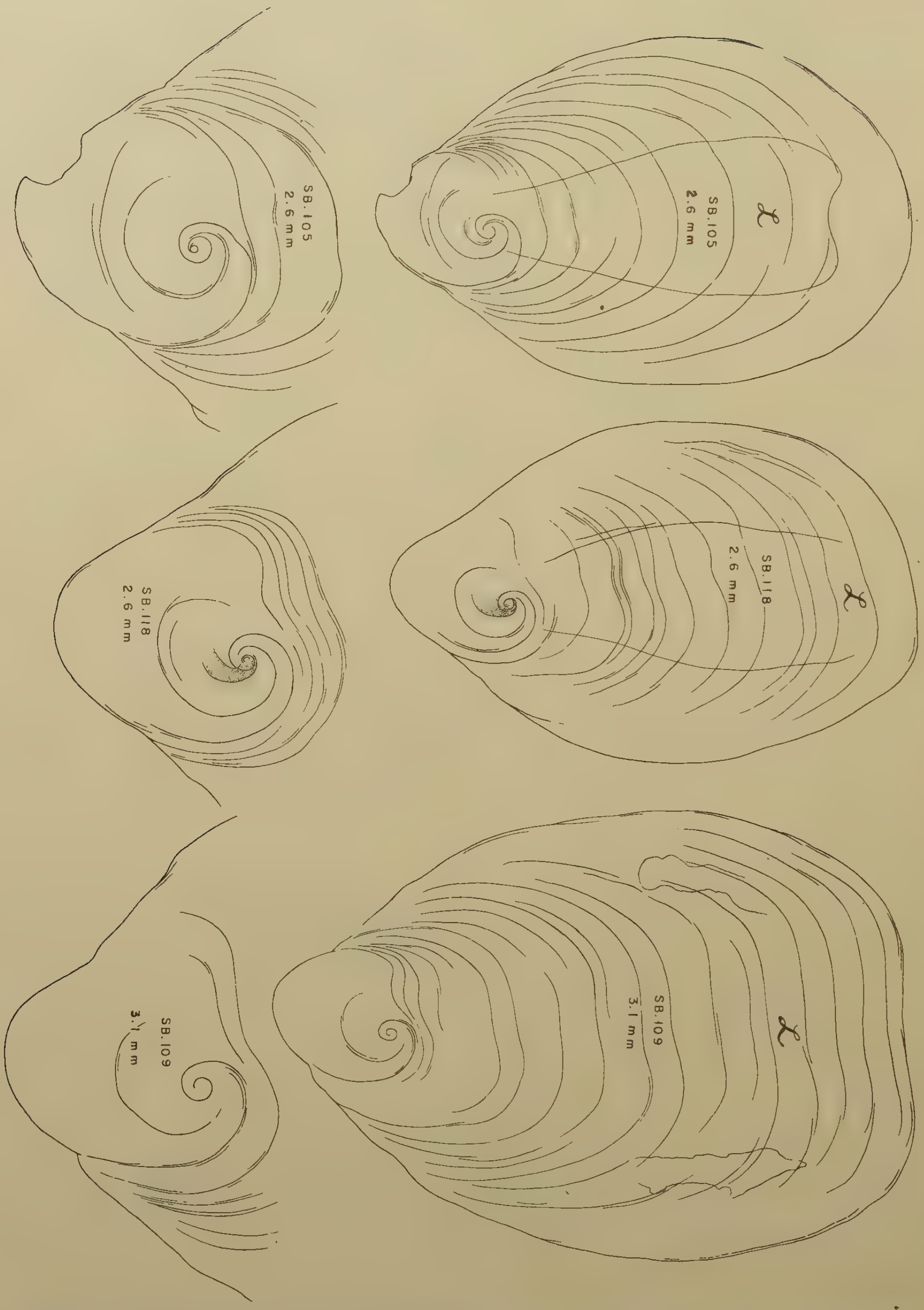
Series W: The operculum is oval, with the axial margin usually rounded in those of the shells larger than 1 mm in diameter and the peripheral (lower) edge most frequently rounded. Gyre is narrow, but longer than in Ser. N; the central portion is still small, although it is evidently larger than in Ser. N. The situation of the central portion is nearer to the centre of the gyre as shown by larger B/A and D/C. The operculum may seem slightly thicker than in Ser. N in some specimens.


SB.109
1.4 mm
SB.105
0.67 mm
SB.122
0.67 mm
SB.109
0.72 mm
SB.109
1.3 mm
SB.109
0.91 mm
SB.112
1.1 mm
SB.109
0.95 mm
SB.109
1.1 mm

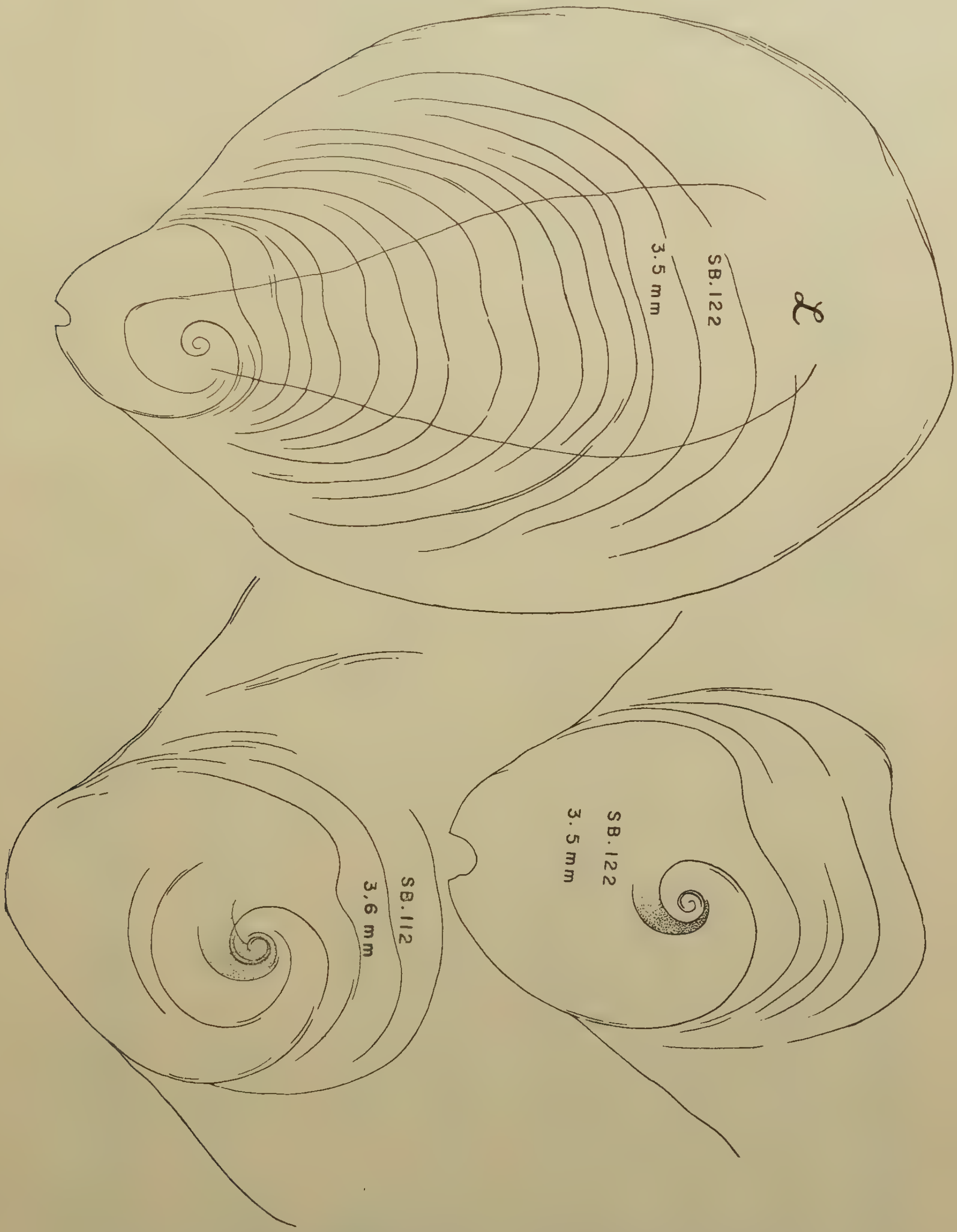
Text-fig. 16. *Atlanta gaudichaudi* SOULEYET, wide type. Opercula of 0.67~1.4 mm shells from Shellback Stations, seen from the attachment surface. ×86.


SB.109
1.6 mm
SB.112
2.2 mm
SB.105
1.6 mm
SB.122
2.3 mm
SB.109
1.8 mm

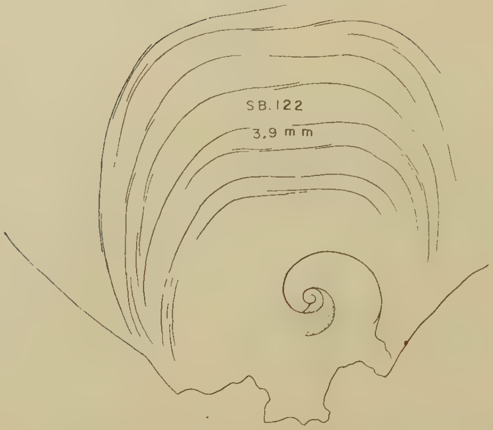
Text-fig. 17. *Atlanta gaudichaudi* SOULEYET, wide type. Opercula of 1.6∼2.3 mm shells from Shellback Stations, seen from the attachment surface. ×86.


SB.105
2.6 mm
SB.105
2.6 mm
L
SB.118
2.6 mm
SB.118
2.6 mm
L
SB.109
3.1 mm
SB.109
3.1 mm
L

Text-fig. 18. *Atlanta gaudichaudi* SOULEYET, wide type. Opercula of 2.6~3.1 mm shells from Shellback Stations, seen from the attachment surface. L…×50, others…×86.


SB.122
3.5 mm
ℒ
SB.112
3,6 mm
SB.122
3.5 mm

Text-fig. 19. *Atlanta gaudichaudi* SOULEYET, wide type. Opercula of 3.5 and 3.6 mm shells from Shellback Stations, seen from the attachment surface. L···×73, others···×127.



Text-fig. 20. *Atlanta gaudichaudi* Souleyet, wide type. Operculum of 3.9 mm shell from Shellback Station 122, seen from the attachment surface. ×95.

Table 13. *Atlanta gaudichaudi* Souleyet, Series W. Whorl formulae.

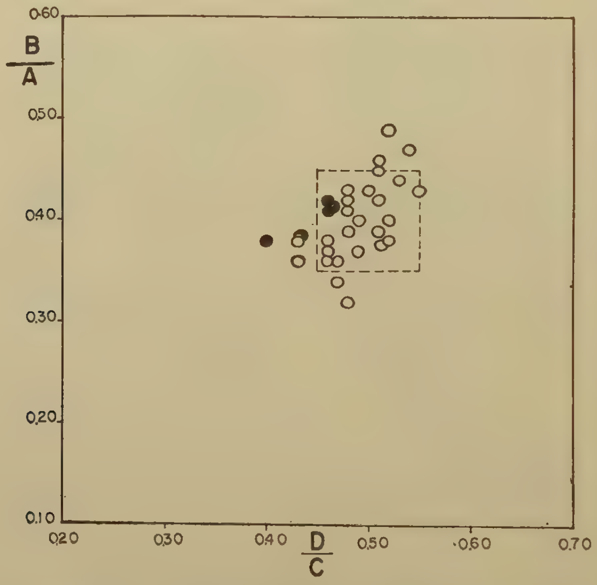
No. of specimen	Long diameter	Whorl formula	Number of whorls	Number of whorls on underside	Locality
1	0.36 mm	1 : 0.44 : 0.25	4-1/4		SB 145
2	0.67	1 : 0.42 : 0.26	4	1-1/4	SB 122
3	0.69	1 : 0.41 : —	3+		SB 105
4	0.69	1 : 0.47 : 0.28	3-3/4		SB 122
5	0.72	1 : 0.45 : —			SB 109
6	0.87	1 : 0.43 : 0.25	4+	1-1/4	SB 122
7	0.89	1 : 0.41 : 0.24	3-1/4		SB 122
8	0.91	1 : 0.43 : —			SB 109
9	0.91	1 : 0.43 : 0.24	4-1/2		SB 122
10	0.95	1 : 0.34 : —	3+		SB 109
11	1.1	1 : 0.33 : —	3+		SB 109
12	1.1	1 : 0.35 : 0.18	3+		SB 112
13	1.1	1 : 0.36 : 0.20	4-1/4	1-1/4	SB 122
14	1.1	1 : 0.33 : —			SB 112
15	1.1	1 : 0.33 : 0.18	3+		SB 109
16	1.2	1 : 0.29 : 0.18	5	2	SB 160
17	1.3	1 : 0.32 : 0.16	ca. 4		SB 109
18	1.3	1 : 0.32 : 0.17			SB 109
19	1.3	1 : 0.27 : 0.15	5		SB 160
20	1.3	1 : 0.31 : 0.17	5+	2	SB 160
21	1.3	1 : 0.33 : 0.18	4-1/4	1-1/4	SB 122
22	1.4	1 : 0.30 : 0.15	4?		SB 109
23	1.4	1 : 0.30 : 0.15	4-1/2	1-1/2	SB 122
24	1.4	1 : 0.29 : —			SB 112
25	1.5	1 : 0.27 : 0.14	ca. 4		SB 112
26	1.5	1 : 0.29 : —			SB 112
27	1.5	1 : 0.27 : 0.14	5	1-3/4	SB 145
28	1.5	1 : 0.30 : 0.18	4-1/2	1-1/2	SB 122
29	1.5	1 : 0.29 : 0.17	4-1/4	1-1/2	SB 122
30	1.5	1 : 0.29 : 0.17	4-1/4	1-1/2	SB 122
31	1.5	1 : 0.29 : 0.17	4-3/4	1-1/2	SB 122
32	1.6	1 : 0.28 : 0.15	ca. 4		SB 109
33	1.6	1 : 0.27 : 0.13	4+		SB 105

34	1.6	1 : 0.28 : 0.15	4–3/4	1–1/2	SB 122
35	1.6	1 : 0.27 : 0.15	4–1/2	1–1/2	SB 122
36	1.6	1 : 0.28 : 0.16	5	1–1/2	SB 122
37	1.6	1 : 0.29 : 0.15	4–3/4	1–1/2	SB 122
38	1.7	1 : 0.25 : 0.15	4–1/2	1–1/2	SB 122
39	1.8	1 : 0.27 : 0.13	ca. 4		SB 109
40	1.8	1 : 0.26 : 0.12	ca. 4		SB 112
41	1.8	1 : 0.24 : 0.14	4–1/2	1–3/4	SB 122
42	1.8	1 : 0.27 : 0.15	5	1–1/2	SB 122
43	1.8	1 : 0.24 : 0.14	4–1/2	1–1/2	SB 122
44	2.0	1 : 0.28 : 0.13	4–3/4	1–1/2	SB 122
45	2.0	1 : 0.27 : 0.14	ca. 5	1–3/4	SB 122
46	2.1	1 : 0.26 : 0.13	5		SB 122
47	2.2	1 : 0.25 : 0.12	ca. 4		SB 112
48	2.2	1 : 0.25 : 0.12			SB 112
49	2.2	1 : 0.25 : 0.14	5–1/4		SB 122
50	2.3	1 : 0.23 : 0.11	5	1–3/4	SB 122
51	2.6	1 : 0.25 : —	4+		SB 105
52	2.6	1 : 0.25 : 0.13	5		SB 118
53	2.6	1 : 0.25 : 0.13	5–1/4	ca. 2	SB 122
54	2.6	1 : 0.25 : 0.13	5–1/4	ca. 2	SB 122
55	2.7	1 : 0.24 : 0.11	5–1/4		SB 122
56	2.9	1 : 0.25 : 0.11	5–1/8	ca. 2	SB 122
57	2.9	1 : 0.27 : 0.11	5–1/4	1–3/4	SB 125
58	2.9	1 : 0.29 : —			SB 109
59	3.0	1 : 0.28 : —			SB 109
60	3.0	1 : 0.26 : 0.11	5+		SB 118
61	3.1	1 : 0.27 : —	?		SB 109
62	3.1	1 : 0.25 : 0.13	5–1/4	2	SB 122
63	3.4	1 : 0.27 : 0.10	5–1/2		SB 80
64	3.5	1 : 0.24 : 0.09	5	2–1/4	SB 122
65	3.6	1 : 0.25 : 0.09	5–1/4		SB 112
66	3.8	1 : 0.26 : 0.09	5–1/2		SB 80
67	3.9	1 : 0.25 : 0.10	5	2–1/4	SB 122
68	4.6	1 : 0.26 : —			SB 80

Table 14. *Atlanta gaudichaudi* SOULEYET, Series W. Measurements on opercula.

No. of specimen	Long dia. of shell	L	A	W/L	A/L	B/A	D/C
2	0.67 mm	395 μ	295 μ	0.84	0.75	0.29	0.41
	0.67	384	374	0.85	0.97	0.35	0.45
5	0.72	395	395	0.83	1.00	0.32	0.44
8	0.91	563	332	0.69	0.59	0.29	0.41
10	0.95	589	368	0.69	0.63	0.29	0.36
11	1.1	668	379	0.68	0.57	0.32	0.41
12	1.1	679	363	0.78	0.53	0.30	0.43
17	1.3	763	363	0.68	0.48	0.32	0.42
22	1.4	837	342	0.67	0.41	0.37	0.44
32	1.6	932	353	0.62	0.38	0.34	0.45
33	1.6	974	384	0.67	0.39	0.32	0.39
39	1.8	1047	374	0.61	0.36	0.28	0.40
47	2.2		395			0.26	0.36
50	2.3		389			0.30	0.40
51	2.6	1427	400	0.65	0.28	0.32	0.43
52	2.6	1400	418	0.65	0.30	0.26	0.37
61	3.1	1673	391	0.72	0.23	0.27	0.35
64	3.5	1709	355	0.68	0.21	0.31	0.44
65	3.6	2000	368	0.75	0.18	0.31	0.35
67	3.9	1800		0.72			0.37

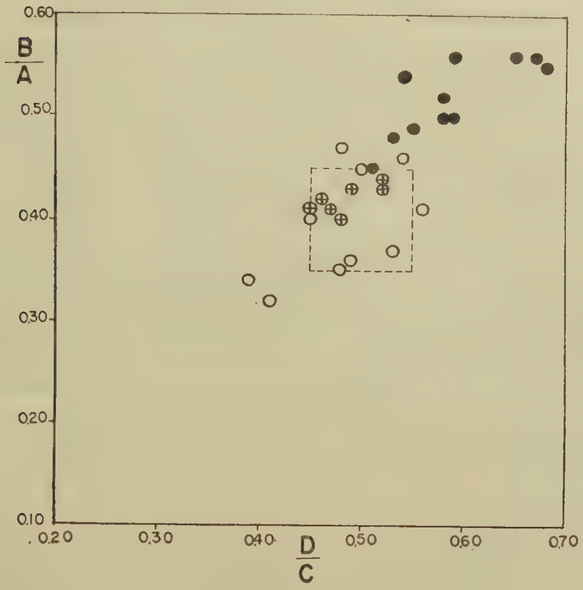
Before the relation between Series N and W is discussed, it seems to be necessary to learn about the range of variations found in respective features of the operculum of some distinctly identified species. Of these features, the length of the gyre and the situation of the central portion indicated by B/A×D/C are considered most important for discussing the relation between Series N and W. The situations of the central portion of the gyre in five well-defined species are shown in text-figs. 21 and 22, and those of Series N and W in text-fig. 23. Even when Series N and W are treated as a single group, the range of variations throughout these two series is never too large as compared with those of some of the five species, as B/A fluctuates for 0.40 as in *A. inclinata* (text-fig. 21) and D/C also does for approximately 0.40 as in *A. lesueuri* (text-fig. 22). As to this respect, Series N and W may be considered to be quite continuous to each other. On the other hand, there is a considerable gap between the gyre length of the two series as is seen in text-fig. 24. The gyre length fluctuates in the above-mentioned five species as shown on Table 15.



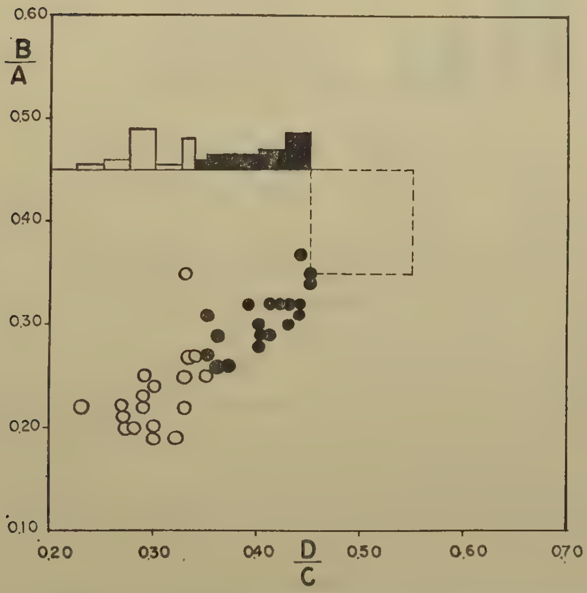
Text-fig. 21. Variations found in the situation of the central portion of gyre in *A. inclinata* (open circle) and *A. fusca* (solid circle). Square shows B/A (0.35–0.45)×D/C (0.45–0.55).

Table 15. Fluctuations of gyre length in six species.

turriculata	339 ± 18 μ
fusca	342 ± 5
lesueuri	241 ± 41



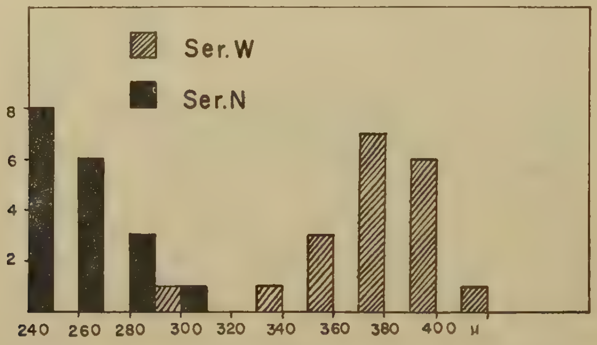
Text-fig. 22. Variations found in the situation of the central portion of gyre in *A. inflata* (open circle), *A. lesueuri* (solid circle) and *A. turriculata* (crossed circle). Square shows B/A (0.35–0.45)×D/C (0.45–0.55).



Text-fig. 23. Variations found in the situation of the central portion of gyre in Series N (open circle) and W (solid circle) of *A. gaudichaudi*. Square shows B/A (0.35–0.45) ×D/C (0.45–0.55).

inclinata	356 ± 60	
inflata	245 ± 18	
Ser. N of *gaudichaudi*	276 ± 34	329 ± 88
Ser. W of *gaudichaudi*	356 ± 61	

When the two series are treated together as a single group, the range of fluctuation of the gyre length seems to be too large for a single species. Usually, however, the more examples are measured, the larger the range of fluctuation becomes. And moreover, it is impossible that the range of fluctuation in a certain species can be accepted as the strict frame for any other species, although it is very helpful to guess the range in other species. The existence of two modes in text-fig. 24 might be caused by the smallness of the examined material. For these reasons, I hesitate to treat Series N and W separately as distinct varieties within a species and expect that these two series may become quite continuous when a large number of specimens are examined.



Text-fig. 24. Variations of the gyre length in two series of *A. gaudichaudi*.

At first, I expected to find out some morphological differences between the shells of these two series in a hope to ascertain the validity of *A. pacifica* which I established. Very unfortunately, however, both series have quite the similar shell which is characterized as follows:—

Shell is flattened and usually with a low spire which may seem rather high on some small shells. It may be quite transparent (No. 57 specimen of Ser. W) or most frequently rather opaque and chalky white in colour; the spire may also be transparent or opaque and coloured purplish-violet, yellowish, or rarely quite colourless. Probably such conditions of the shell and the spire are in accord with the states of preservation of shells rather than to be of any essential significance. Keel insertion is seen rather rarely and in a slight degree, usually it reaches to 1/8–1/4 of the body whorl, although exceptionally it may attain 1/2 (No. 67 specimen of Ser. W). The base of the keel is brownish. Eyes are usually reddish, or rarely orange red in a preserved state. The whorl formula for this species includes both formulae respectively given previously for *A. gaudichaudi* and *A. pacifica* (Tokioka 1955 a, b). In other words, *A. pacifica* can not be distinguished as a distinct form from *A. gaudichaudi*. Thus, I am quite unhappy, but here withdraw *A. pacifica* by myself. It is very possible, however, that the majority of specimens in a certain sample are apt to show the similar whorl formula of the shell or the appearance of the operculum which may frequently differ somewhat from those seen in specimens in other samples. And such a phenomenon seems to show the existence of some differences according to stocks in a certain species. Very probably, the characters that ever differentiated *pacifica* from *gaudichaudi* are of the nature of the differences according to stocks and also the same is for the differences between Series N and W.

Occurrences:

SB 1 (23)
SB 68 (1)
SB 75 (?1)
SB 80 (2)
SB 90 (2)
SB 95 (8)
SB 100 (1)
SB 105 (n1, w3)
SB 109 (w 15)
SB 112 (w 37)
SB 115 (1)
SB 118 (2)
SB 122 (32)
SB 125 (1)
SB 145 (6)
SB 150 (n1, w1)
SB 155 (n1, w1)
SB 160 (n1, w5)
SB 175 (n6, w5)
SB 180 (w 5)
SB 181 (n4, w4)
SB 187 (n4, w2)
SB 195 (n 1)
SB 200 (n27, w14)
SB 217 (w 1)
EQPH 7 (n 1)
EQPH 11 (n 8)
EQPH 17 (n1, w2)

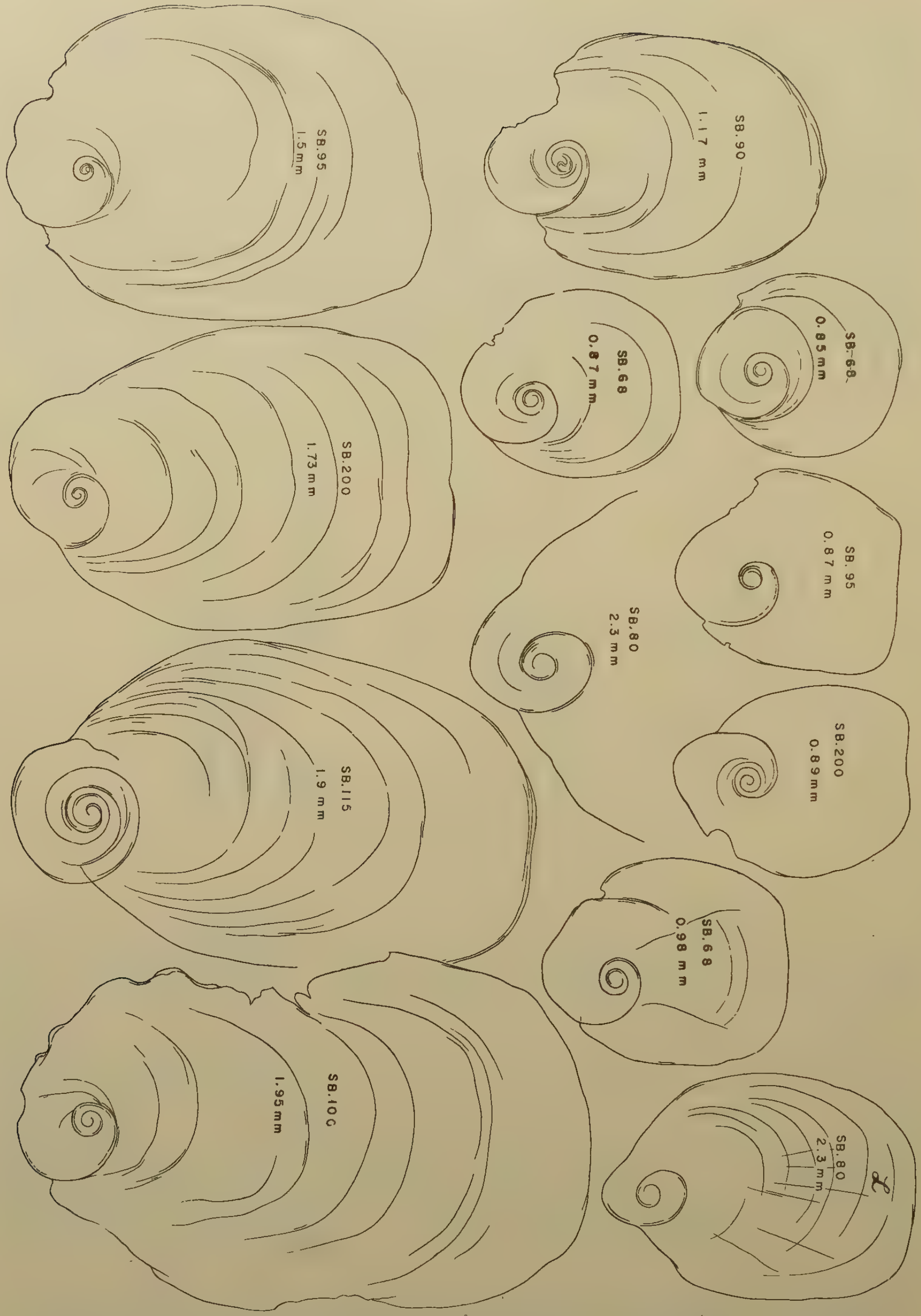
n…Series N, w…Series W.

8. *Atlanta peroni* Lesueur

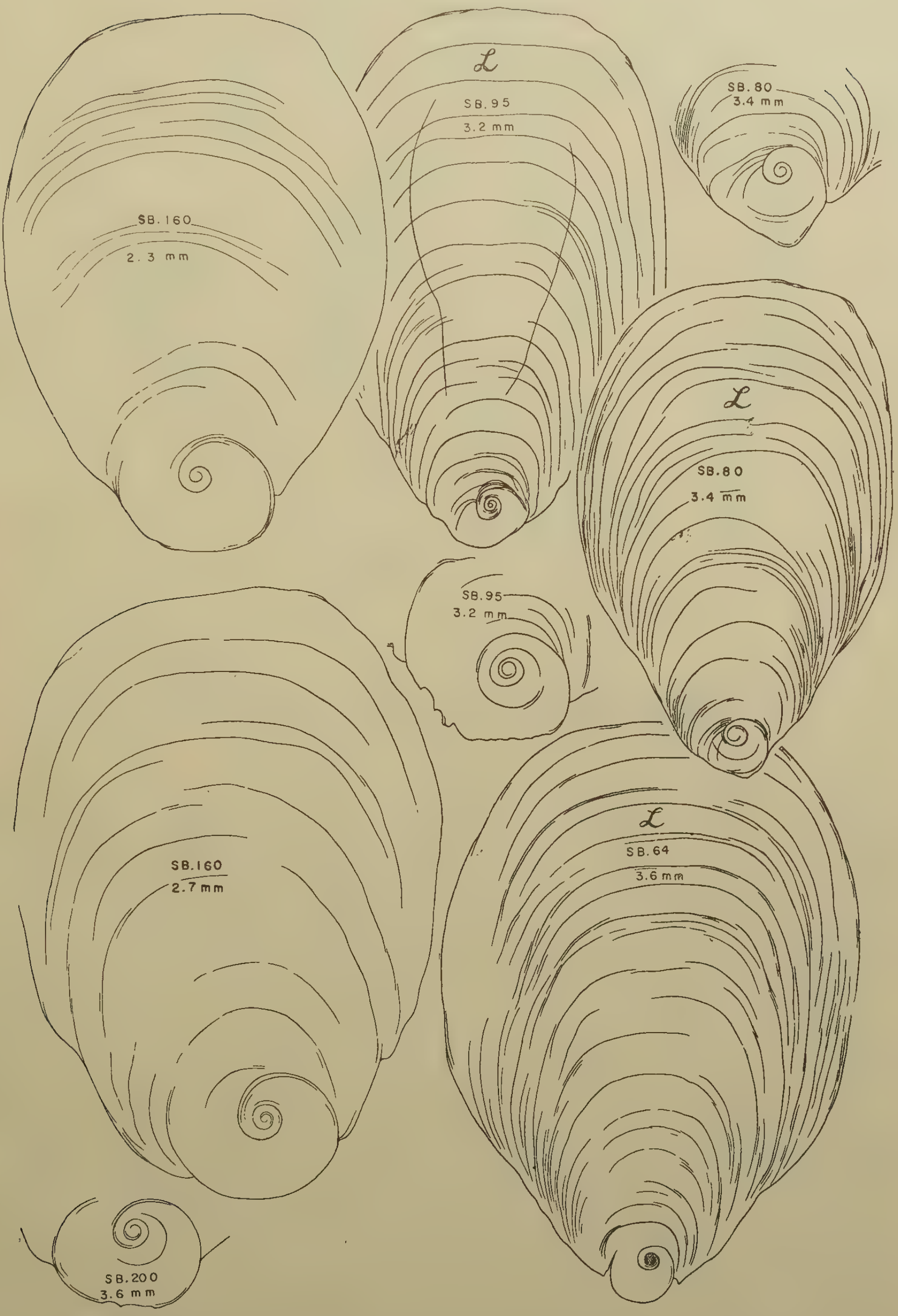
(Text-figs. 25–31)

It is very strange that this best known species is identified with very great difficulty. As noted by Tesch (1949, p. 17), the most remarkable difference between this and the preceding species is found in the breadth of the shell aperture which is comparatively larger in *A. gaudichaudi* than in *A. peroni*. In addition to this, the remarkable insertion of the keel between the whorls in larger shells is noticeable. Thus, at first, enough large shells with the comparatively large second and third terms of the whorl formula and a remarkable penetration of keel were selected out of the samples as the definitely identified specimens of *A. peroni* and then their opercula were examined. Next, by using the features of the operculum as clues for identification, the data for the present species were searched for. Again, here are discriminated two series of opercula, Series S and L.

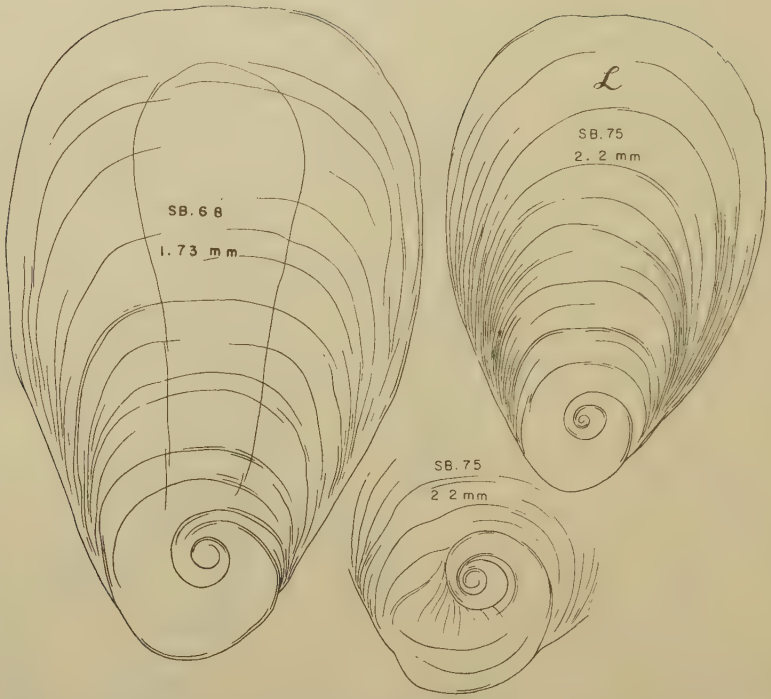
Series S (Text-figs. 25–27): Operculum oval, gyre is very small, most frequently less than 200 μ in length. The axial margin is obtuse to round, while the lower (peripheral) edge of gyre is rounded or rarely slightly narrowed as


SB.95
1.5mm
SB.90
1.17 mm
SB.68
0.87 mm
SB.68
0.85 mm
SB.200
1.73 mm
SB.95
0.87 mm
SB.80
2.3 mm
SB.115
1.9 mm
SB.200
0.89 mm
SB.68
0.98 mm
SB.106
1.95 mm
SB.80
2.3 mm
L

Text-fig. 25. *Atlanta peroni* LESUEUR, Series S. Opercula of 0.85~2.3 mm shells from Shellback Stations, seen from the attachment surface, excepting the operculum of the 0.89 mm shell from SB 200. L⋯×50, others⋯×86.


SB. 160
2. 3 mm
L
SB. 95
3.2 mm
SB. 80
3.4 mm
SB. 95
3.2 mm
L
SB. 80
3.4 mm
SB. 160
2.7 mm
L
SB. 64
3.6 mm
SB. 200
3.6 mm

Text-fig. 26. *Atlanta peroni* LESUEUR, Series S. Opercula of 2.3∼3.6 mm shells from Shellback Stations, seen from the attachment surface. L⋯×50, others⋯×86.

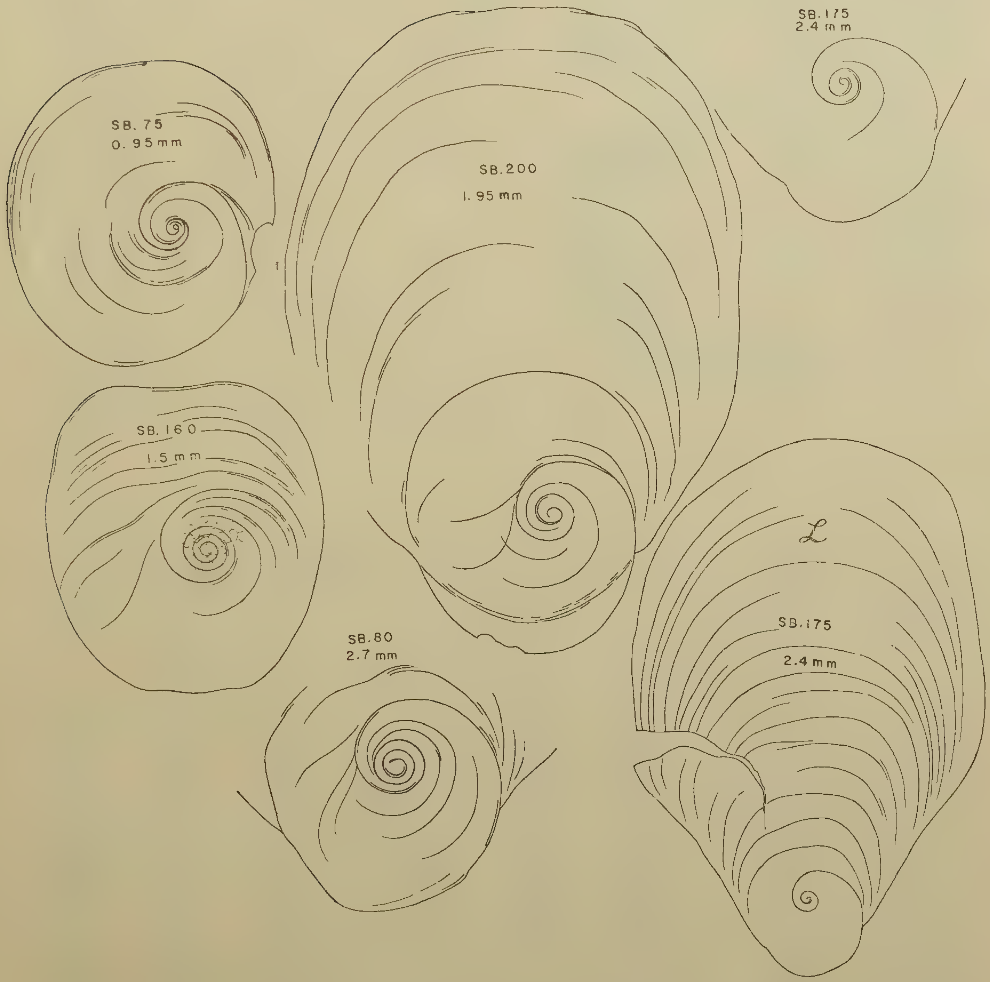


Text-fig. 27. *Atlanta peroni* LESUEUR, Series S. Opercula of 1.73 and 2.2 mm shells from Shellback Stations, seen from the attachment surface. L···×55, others···×95.

seen in 0.89 (SB 200), 2.3 (SB 80) and 3.4 mm (SB 80) shells. Gyre is most frequently very wide (antero-posteriorly) and with the peripheral margin often worn away. The central portion of gyre is rather small, but sometimes it may be of a considerable size in some specimens. It is usually situated near the middle of the axial half of the gyre, though it may be somewhat displaced to the right (anterior) side in some specimens. The operculum itself is extremely thin.

Evidently, terms B/A and C/A of the whorl formula are slightly larger in *A. peroni* than in *A. gaudichaudi*, although these values of smaller shells are quite similar in both species. Mostly, the shell is coloured yellowish white, pale yellowish, or light brownish and the spire is often quite uncoloured. The base of the keel may be brownish in some specimens. Eyes are reddish in preserved specimens.

Series L (Text-figs. 28-29): The axial margin of the operculum is obtuse in younger stages, but roundish in grown ups. The gyre in much larger than in Ser. S, being always longer than 250 μ. It is very wide and the peripheral edge is rounded. The central portion is of a considerable size and situated near the middle of the axial half. The operculum itself seems to be slightly thicker than in Ser. S.


SB.175
2.4 mm
SB. 75
0. 95 mm
SB.200
1. 95 mm
SB.160
1.5 mm
L
SB.175
2.4 mm
SB.80
2.7 mm

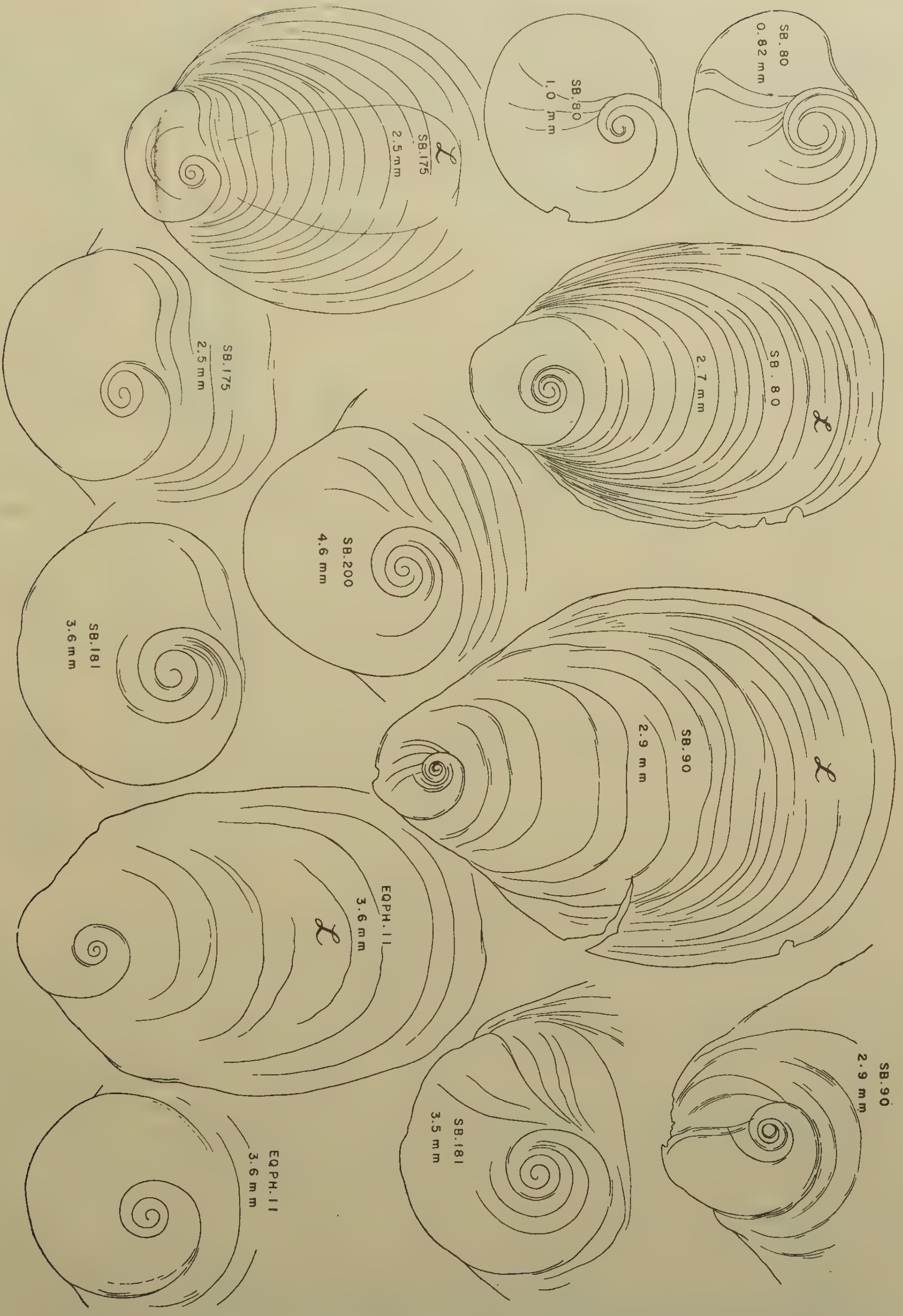
Text-fig. 28. *Atlanta peroni* LESUEUR, Series L. Opercula of 0.95∼2.7 mm shells from Shellback Stations, seen from the attachment surface. L…×71, others…×122.

Table 16. *Atlanta peroni* Lesueur, Series S. Whorl formulae.

No. of specimen	Long diameter	Whorl formula	Number of whorls	Number of whorls on underside	Locality
1	0.87 mm	1 : 0.50 : —			SB 95
2	0.89	1 : 0.44 : 0.27	3-1/4		SB 200
3	1.17	1 : 0.37 : —			SB 90
4	1.5	1 : 0.35 : —	5	2	SB 95
5	1.73	1 : 0.33 : 0.18	4-3/4		SB 200
6	1.73	1 : 0.33 : —			SB 68
7	1.84	1 : 0.31 : 0.16	4-1/4	2	EQPH 7
8	1.9	1 : 0.34 : 0.17	5		SB 115
9	1.95	1 : 0.33 : 0.16	3-1/4?		SB 100
10	2.2	1 : 0.34 : 0.16	4-1/2	2-1/4	EQPH 17
11	2.2	1 : 0.31 : —			SB 75
12	2.3	1 : 0.28 : 0.12	4-3/4		SB 80
13	2.3	1 : 0.31 : 0.13	5-1/4	2-1/4	SB 160
14	2.3	1 : 0.31 : 0.14	4-1/4		SB 50
15	2.7	1 : 0.29 : 0.12	5-1/4	2-1/4	SB 160
17	3.2				SB 95
18	3.6	1 : 0.29 : —			SB 64
19	3.6	1 : 0.25 : 0.14	5-1/2	2-1/4	SB 200
20	4.6	1 : 0.31 : 0.11	5	ca. 3	EQPH 17

Table 17. *Atlanta peroni* Lesueur, Series S. Measurements on opercula.

No. of specimen	Long dia. of shell	L	A	W/L	A/L	B/A	D/C
Opercula shown in text-figs. 25 and 26.							
	0.85 mm	274 μ	142 μ	1.06	0.52	0.46	0.55
1	0.87	347	153	0.86	0.44	0.45	0.50
	0.87	363	163	0.86	0.45	0.37	0.50
2	0.89	374	163	0.80	0.44	0.42	0.52
	0.98	389	157	0.84	0.41	0.40	0.45
3	1.17	537	163	0.72	0.30	0.42	0.48
4	1.5	663	163	0.75	0.25	0.35	0.39
5	1.73	705	157	0.69	0.22	0.47	0.48
8	1.9	832	211	0.61	0.25	0.73	0.78
9	1.95	911	157	0.64	0.17	0.47	0.49
12	2.3	855	227	0.72	0.27	0.60	0.56
13	2.3	842	179	0.71	0.21	0.45	0.56
15	2.7	953	195	0.70	0.20	0.51	0.55
17	3.2	1464	173	0.65	0.12	0.69	0.56
	3.4	1355	164	0.64	0.12	0.37	0.48
18	3.6	1582	155	0.72	0.10	0.41	0.48
19	3.6		163			0.45	0.52
Opercula shown in text-fig. 27.							
6	1.73	911	215	0.64	0.24	0.51	0.58
11	2.2	1136	245	0.66	0.22	0.47	0.50


L
SB.175
2.5 mm
SB.80
1.0 mm
SB.80
0.82 mm
SB.175
2.5 mm
SB.80
2.7 mm
L
SB.200
4.6 mm
SB.181
3.6 mm
SB.90
2.9 mm
L
EQPH.11
3.6 mm
L
EQPH.11
3.6 mm
SB.181
3.5 mm
SB.90
2.9 mm

Text-fig. 29. *Atlanta peroni* LESUEUR, Series L. Opercula of 0.82~4.6 mm shells from Shellback (SB) and Equapac (EQPH) Stations, seen from the attachment surface. L…×50, others…×86.

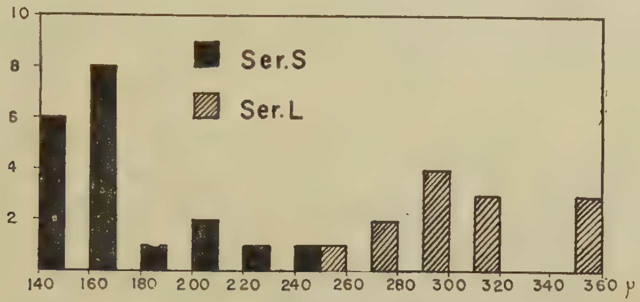
Table 18. *Atlanta peroni* LESUEUR, Series L. Whorl formulae.

No. of specimen	Long diameter	Whorl formula	Number of whorls	Number of whorls on underside	Locality
1	0.82 mm	1 : 0.42 : 0.26	4		SB 80
2	0.95	1 : 0.36 : 0.23	3-3/4		SB 75
3	1.00	1 : 0.43 : —	4-1/2		SB 80
4	1.5	1 : 0.33 : 0.18	4-1/4	1-3/4	SB 160
5	1.95		4-1/4	2-1/4	SB 200
6	2.4				SB 175
7	2.5	1 : 0.32 : 0.13	4-1/4		SB 175
8	2.7	1 : 0.31 : 0.12	5		SB 80
9	2.9	1 : 0.31 : —			SB 90
10	3.5	1 : 0.28 : 0.11	5+		SB 181
11	3.6	1 : 0.29 : 0.14	5	2-1/4+	SB 181
12	3.6	1 : 0.29 : 0.11	5+	2-1/2	EQPH 11
13	4.6	1 : 0.31 : 0.14	5-1/4	2-1/2	SB 200

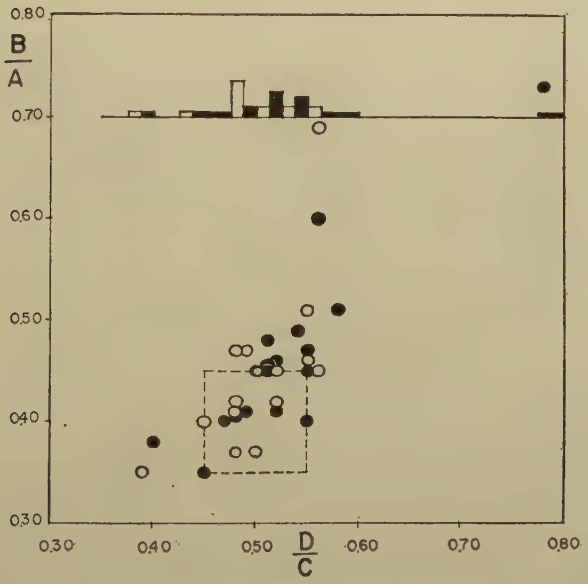
Table 19. *Atlanta peroni* LESUEUR, Series L. Measurements on opercula.

No. of specimen	Long dia. of shell	L	A	W/L	A/L	B/A	D/C
1	0.82 mm	295 μ	295 μ	1.13	1.00	0.48	0.51
2	0.95	453	295	0.86	0.65	0.38	0.40
3	1.0	305	305	1.09	1.00	0.40	0.47
4	1.5	447	295	0.89	0.66	0.45	0.51
5	1.95	953	284	0.70	0.30	0.41	0.49
6	2.4	1364	264	0.65	0.19	0.35	0.45
7	2.5	1027	264	0.82	0.26	0.41	0.48
8	2.7	1145	318	0.68	0.28	0.46	0.56
9	2.9	1445	255	0.72	0.18	0.40	0.55
10	3.5		342			0.49	0.54
11	3.6	1273	309	0.66	0.24	0.45	0.51
12	3.6		353			0.46	0.52
13	4.6		347			0.41	0.52

The most perplexing is the identification of young shells; for instance, that of the 0.95 mm and 1.5 mm shells shown in text-fig. 28 and the 0.82 mm and 1.00 mm ones shown in text-fig. 29. If the development of the operculum of Series L is completely parallel to that of Series S, then the 0.82 mm and 1.00 mm shells of Ser. L should have some well-defined major part. If the 0.82 mm and 1.00 mm shells shown in text-fig. 29 are really the young shells of Series L, then the 0.95 mm shell shown in text-fig. 28 is too large for Ser. L; and moreover it is rather strange that the 1.00 mm shell of Series L has the operculum smaller than that of the shell of the corresponding size in Series S. On the other hand, the gyre of Ser. L resembles very closely that of *A. inclinata*. Evidently, however, opercula of the 0.82 mm and 1.00 mm shells shown in text-fig. 29 are too small for *inclinata*. Especially, the operculum of the 1.5 mm shell shown in text-fig. 28 is related closely to that of *inclinata*, but even this is somewhat small for *inclinata*. Moreover, the whorl formulae of these young shells are not differentiated clearly from those of young *inclinata*. Thus, these shells are arranged here under Series L of *A. peroni*, only because the shape and size of gyres of their opercula resemble most closely those of the typical ones of Series L. I cannot identify them with confidence; it is not impossible that some of them might belong to *A. inclinata*.



Text-fig. 30. Variations of the gyre length in two series of *A. peroni*.



Text-fig. 31. Variations found in the situation of the central portion of gyre in Series S (open circle) and L (solid circle) of *A. peroni*. Square shows B/A (0.35–045)×D/C (0.45–0.55).

The shells of Ser. L are quite the same as those of Ser. S. As the operculum length is nearly the same in the two series for shells of the same diameter, it is quite natural that there is no difference between the whorl formulae of the two series.

The difference between Series S and L is confined to the size or the length of the gyre of the operculum as shown in text-fig. 30. The feature of the central portion shown by B/A and D/C is quite common to the opercula of both series as seen in text-fig. 31. It is hardly possible, at present, to mention definitely about the significance of the difference between the two series. I can only repeat here the same comment expressed upon the Series N and W of the preceding species. The two specimens shown in text-fig. 27 were separated from others, as they were considered to represent some intermediate states between the two series.

Some opercula of Series L resemble superficially some of Ser. W of *A. gaudichaudi*. However, the situation of the central portion of the gyre indicated by B/A and D/C seems to differ definitely between the two (text-fig. 31 v. 23). Moreover, the gyre length of Ser. L ($240 \sim 360\,\mu$) is smaller than that of Ser. W ($280 \sim 420\,\mu$). And further, as the gyre length, the situation of the central portion of the gyre, and the whorl formula of the shell are correlated one another in respective series, it is impossible that some significant close relationship is proved between Series W and L.

Occurrences:

SB 50 (3)
SB 60 (2)
SB 64 (1)
SB 68 (1)
SB 75 (2)
SB 80 (6)
SB 90 (7)
SB 95 (5)
SB 100 (10)
SB 112 (2)
SB 115 (1)
SB 160 (3)
SB 175 (2)
SB 181 (2)
SB 187 (1)
SB 200 (5)
EQPH 7 (3)
EQPH 11 (15)
EQPH 17 (8)

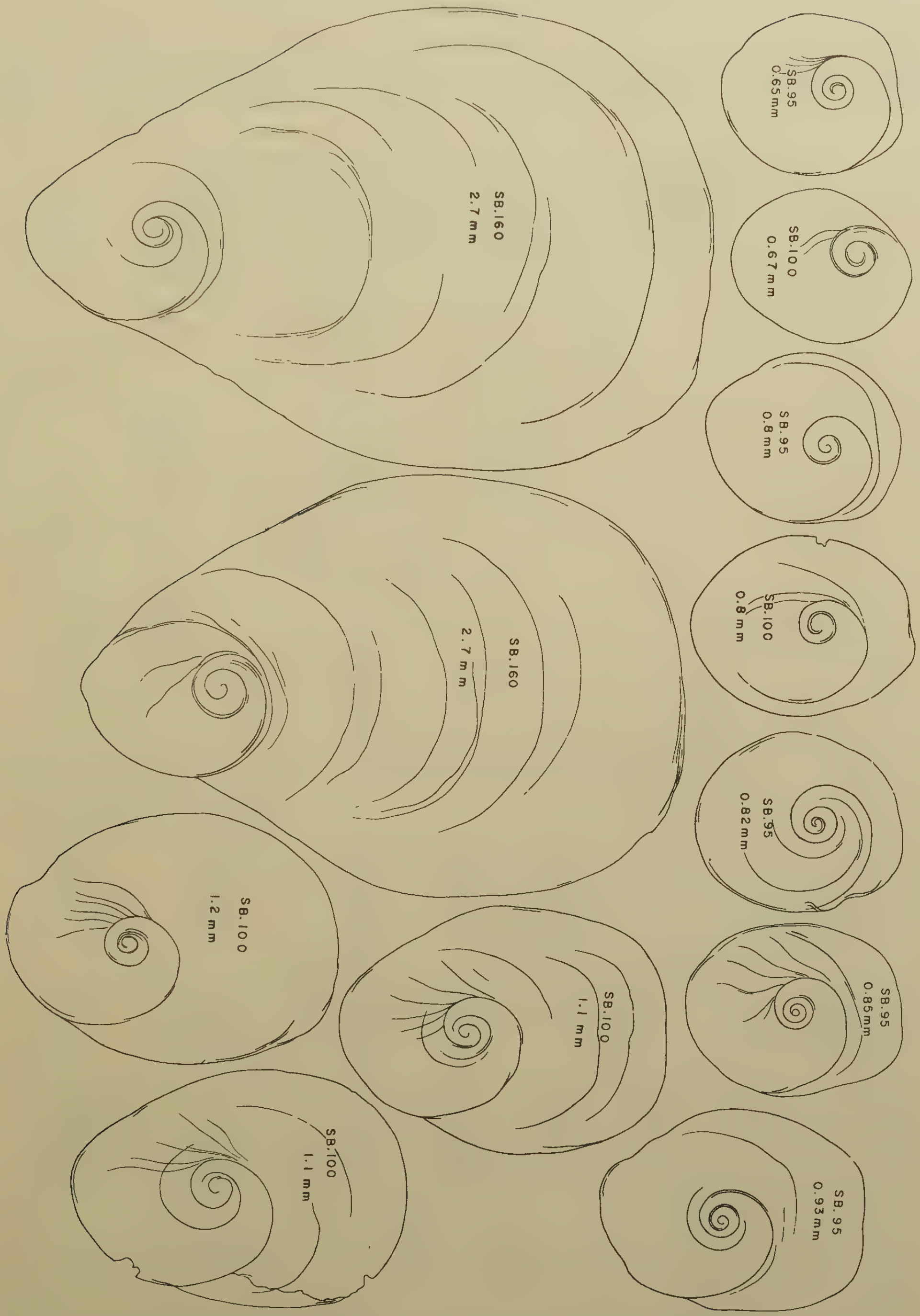
9. *Atlanta helicinoides* Souleyet

(Text-figs. 32–34)

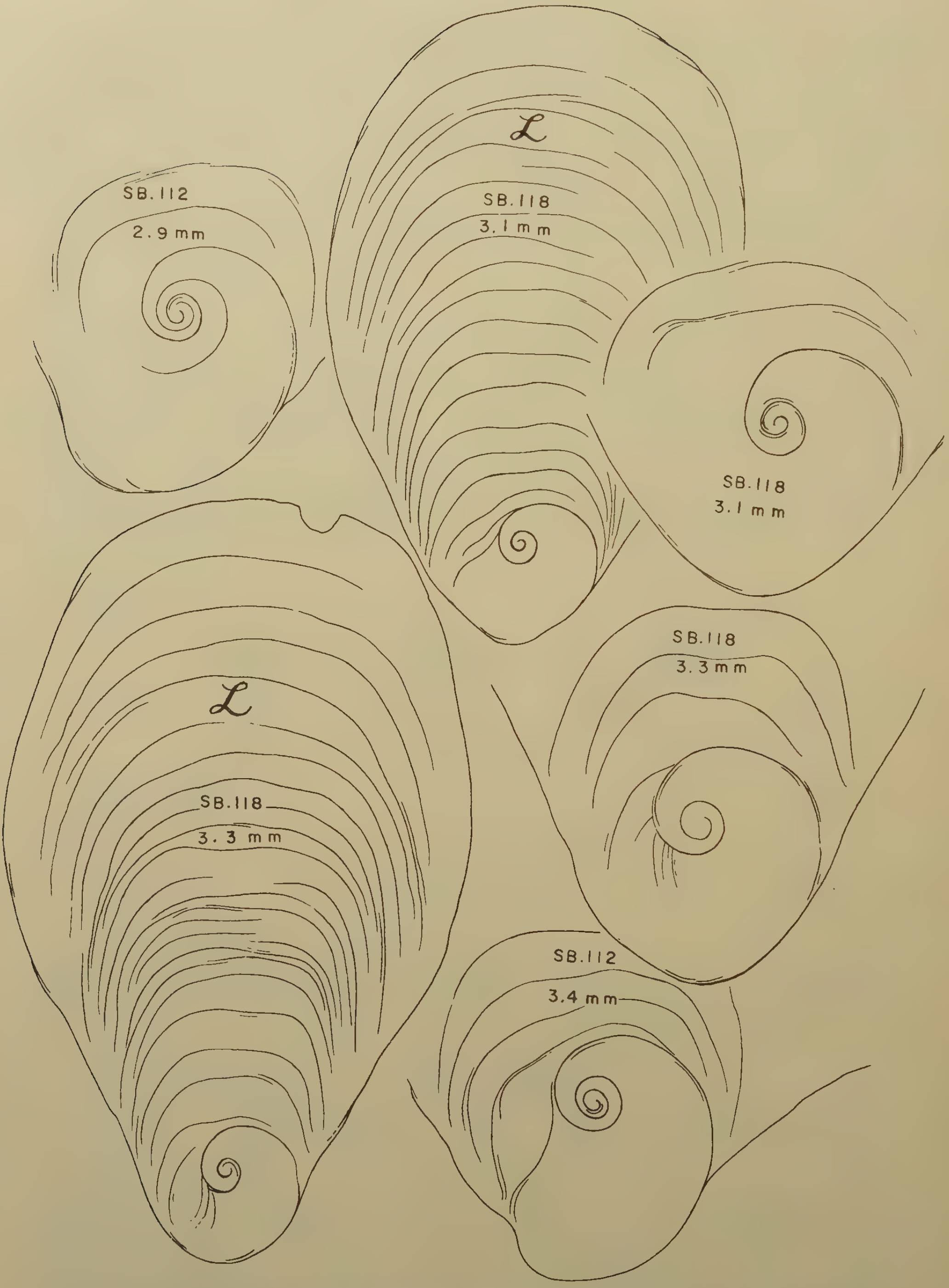
It is very difficult to identify this species on young shells in which the sculpture has disappeared. As a whole, the state of preservation is not satisfactory for the specimens of Atlantidae in the present material, most shells are more or less softened and the sculpture on the spire has become quite obscure. So, at first, some enough large shells which can be identified as *A. helicinoides* which a certainty because of the larger spire (or the larger second term of the whorl formula) and the presence of many whorls* on the spire were selected out and

---

* Apart from the appearance of the sculpture on the spire, *A. helicinoides* differs from *A. inflata*, the most closely related species, in that the spire is much larger or somewhat broader (Tesch 1908, p. 23; 1949, p. 19). Number of whorls on the spire was described fewer (5) than in *inflata* (5–7) by Tesch in 1908 when he treated *A. depressa* Souleyet as a distinct species. However, in his paper of 1949 *A. depressa* is considered to be *helicinoides* in which the sculpture of the spire has disappeared. If *A. depressa* is really a synonym of *A. helicinoides*, then the number of whorls on the spire should be raised a little more for *helicinoides*.


SB.160
2.7 mm
SB.160
2.7 mm
SB.100
1.2 mm
SB.100
1.1 mm
SB.100
1.1 mm
SB.95
0.65mm
SB.100
0.67 mm
SB.95
0.8 mm
SB.100
0.8 mm
SB.95
0.82mm
SB.95
0.85mm
SB.95
0.93mm

Text-fig. 32. *Atlanta helicinoides* SOULEYET. Opercula of 0.65~2.7 mm shells from Shellback Stations, seen from the attachment surface. ×86.


SB.112
2.9 mm
𝓛
SB.118
3.1 mm
SB.118
3.1 mm
𝓛
SB.118
3.3 mm
SB.118
3.3 mm
SB.112
3.4 mm

Text-fig. 33. *Atlanta helicinoides* Souleyet. Opercula of 2.9∼3.4 mm shells from Shellback Stations, seen from the attachment surface. L⋯×73, others⋯×127.

their opercula were examined carefully. Then, by using the feature of the operculum as the clue, some other shells referable to the present species were taken out of the samples.

Table 20. *Atlanta helicinoides* SOULEYET. Whorl formulae.

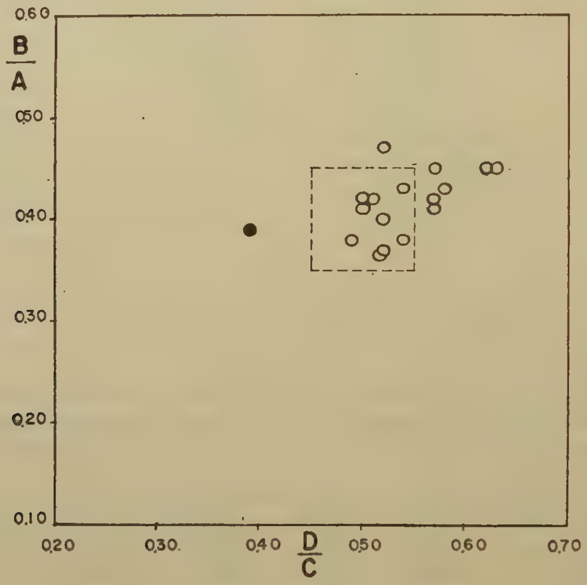
No. of specimen	Long diameter	Whorl formula	Number of whorls	Number of whorls on underside	Locality
1	0.65 mm	1 : 0.67 : —			SB 95
2	0.67	1 : 0.68 : —			SB 100
3	0.80	1 : 0.65 : —			SB 100
4	0.80	1 : 0.65 : —			SB 95
5	0.82	1 : 0.66 : —			SB 95
6	0.85	1 : 0.49 : 0.26	3–1/2		SB 68
7	0.85	1 : 0.57 : —			SB 95
8	0.87	1 : 0.50 : 0.25	3–1/4		SB 68
9	0.92	1 : 0.39 : 0.23	3–1/4		SB 80
10	0.93	1 : 0.58 : —			SB 95
11	0.98	1 : 0.42 : 0.22	3–1/2		SB 68
12	1.1	1 : 0.52 : —			SB 100
13	1.1	1 : 0.56 : —			SB 100
14	1.2	1 : 0.51 : —			SB 100
15	2.7	1 : 0.34 : 0.22	7–1/2	3+	SB 160
16	2.9	1 : 0.30 : —			SB 112
17	3.1	1 : 0.29 : 0.19	7–1/2	ca. 3	SB 118
18	3.3	1 : 0.28 : 0.14	8	ca. 4	SB 118
19	3.4	1 : 0.29 : —			SB 112

Table 21. *Atlanta helicinoides* SOULEYET. Measurements on opercula.

No. of specimen	Long dia. of shell	L	A	W/L	A/L	B/A	D/C
1	0.65 mm	279 μ	268 μ	0.91	0.96	0.47	0.52
2	0.67	284	284	0.85	1.00	0.43	0.58
3	0.80	311	268	0.87	0.86	0.41	0.50
4	0.80	358	274	0.79	0.76	0.37	0.52
5	0.82	326	279	0.87	0.85	0.45	0.62
6	0.85	342	258	0.80	0.75	0.45	0.57
10	0.93	416	284	0.76	0.68	0.43	0.54
12	1.1	511	289	0.76	0.57	0.42	0.57
13	1.1	526	316	0.71	0.60	0.38	0.54
14	1.2	516	274	0.77	0.53	0.42	0.50
15	2.7	947	289	0.71	0.31	0.40	0.52
	2.7	1079	284	0.67	0.26	0.41	0.57
16	2.9	1500	284	0.60	0.19	0.37	0.52
17	3.1	1236	273	0.64	0.22	0.42	0.51
18	3.3	1482	264	0.61	0.18	0.45	0.63
19	3.4	1500	274	0.73	0.18	0.38	0.49

The operculum is oval in younger specimens, but somewhat elongate in adults. The axial margin is usually rounded in grown ups. The gyre is oval and relatively small. It is a little larger than that of Ser. S of *A. peroni* and nearly as long as that of Series L of the same species. It is, however, never so wide as in both types of *A. peroni*; it is always longer than wide in the present species, while it is wider than long in *A. peroni*. The central portion is situated at the middle of the axial half of the gyre. D/C seems to be a little larger than in *A. peroni*. The operculum itself is extremely thin.

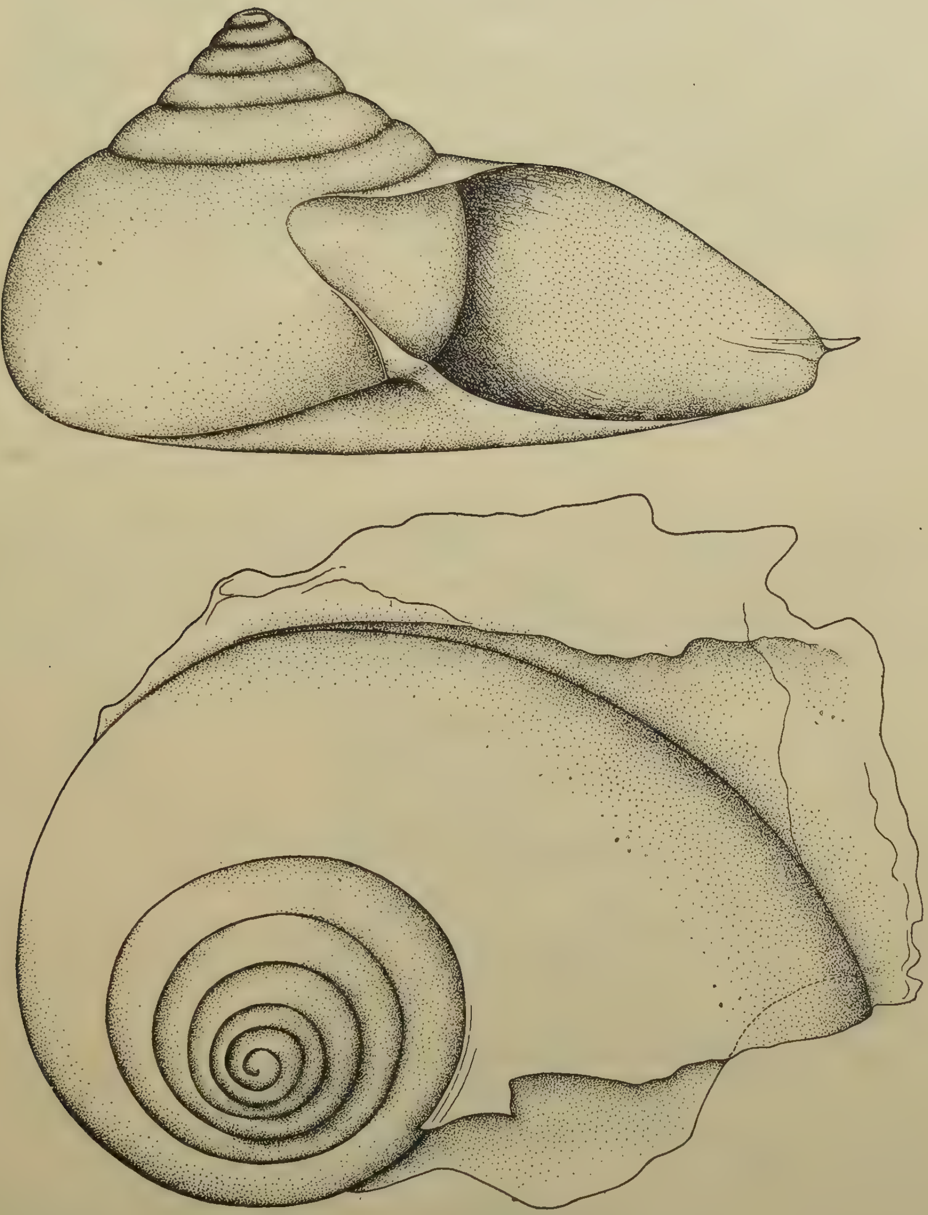
The existence of 7–8 whorls on shells with ca. 3 mm diameter is unique for the present specimens. Large shells are usually brownish, rather thin and sometimes translucent or transparent. The surface of the body whorl may be slightly undulating as in the shell of *Carinaria*. The spire is high, may incline a little to the plane of the body whorl and usually it is not coloured specially. The umbilicus is large and deep; up to 4 whorls are observed on the underside. The keel may be very high and its insertion reaches to 1/4 of the suture between the body whorl and the spire in examined specimens. The eyes are usually reddish in the preserved specimens. Young shells might be confused with those of *A. inclinata*, as the spire is large and high and provided with rather numerous whorls as compared with those of other species. However, the operculum of *A. inclinata* has usually the gyre larger than that of *A. helicinoides*.



Text-fig. 34. Variations found in the situation of the central portion of gyre in *A. helicinoides* (open circle) and *P. souleyeti* (solid circle). Square shows B/A (0.35–0.45)×D/C (0.45–0.55).

Occurrences:

SB 68 (3)
SB 80 (1)
SB 100 (5)
SB 115 (1)
SB 118 (2)
SB 145 (1)
SB 155 (?1)
SB 160 (2)



Text-fig. 35. ? *Protatlanta souleyeti* (E. A. SMITH). Shell with a 1.5 mm long diameter. ×73.

10. ? *Protatlanta souleyeti* (EDG. A. SMITH)

(Text-figs. 34–36)

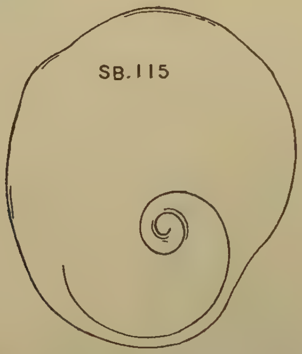
A single shell referable to this species was found in the sample from SB 115.

Table 22. ? *Protatlanta souleyeti* (E. A. SMITH). Whorl formula (above) and measurements on operculum (below).

Long diameter	Whorl formula	Number of whorls	Number of whorls on underside	Locality
1.5 mm	1 : 0.42 : 0.29	6–1/2	2	SB 115

Long dia. of shell	L	A	W/L	A/L	B/A	D/C
1.5 mm	347 μ	163 μ	0.85	0.47	0.39	0.39

It is a small shell with a 1.5 mm diameter, which is thin, somewhat horny in consistency and yellowish brown in colour. Six and a half whorls are observed. The spire is very large and high, but distinctly differs in shape from that of *A. inclinata*. Rather it resembles that of *A. helicinoides*, especially that of *A. depressa* figured by TESCH (1908). The underside is rather flat, not so convex as in *A. inclinata*. The umbilicus is large and deep. Most parts of the keel is quite transparent. This shell resembles most closely *A. helicinoides*. However, the operculum of this shell seems to be too small for *helicinoides*, much smaller than opercula of 1.1 mm shells of *helicinoides*. The gyre length is similar to that of Series S of *A. peroni*, but the length of the whole operculum is still much

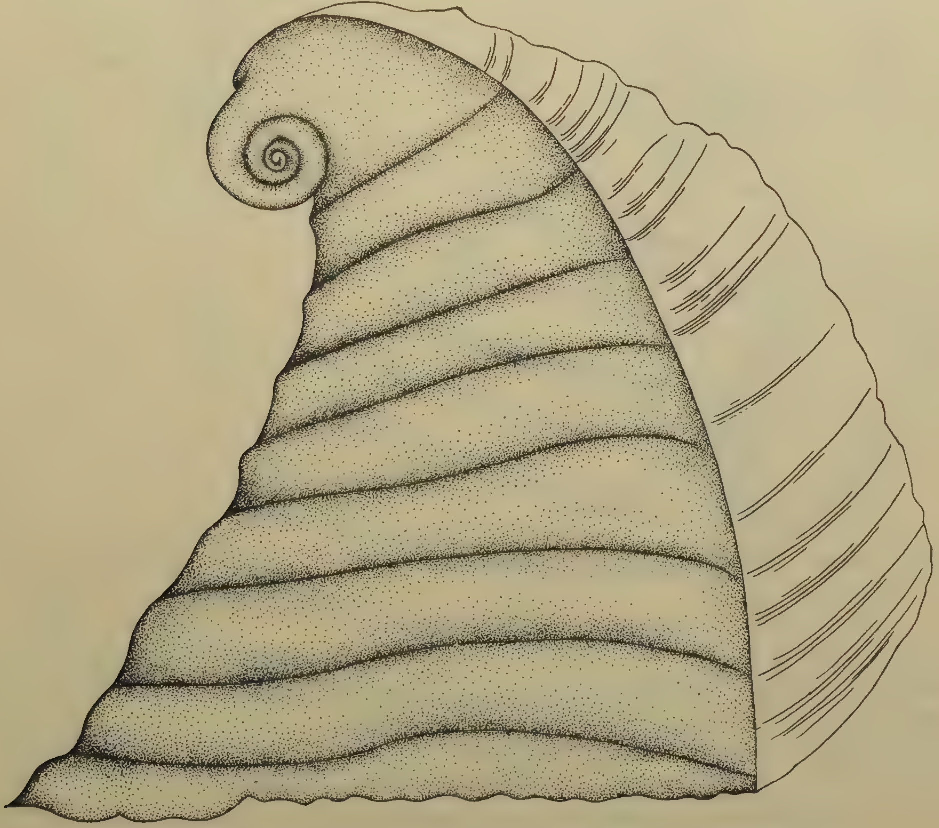


Text-fig. 36. ? *Protatlanta souleyeti* (E. A. SMITH). Operculum of the 1.5 mm shell from SB 115, seen from the attachment surface. ×127.

smaller than in *A. peroni*. Moreover, the feature of the shell differs distinctly between this and *A. peroni*; the spire is larger and more whorls are present in the present specimen. As the operculum of *A. inclinata* is much larger and has much larger gyre, the comparison between this and *A. inclinata* is quite out of the question. I am inclined to consider this specimen to be a form of *A. helicinoides*, but at the same time, the resemblance between this and *P. souleyeti* cannot be denied completely. At present, on account of the existence of so remarkable difference between the opercula of the present specimen and *A. helicinoides*, I want to treat this provisionally as *P. souleyeti*. Future examinations on many definitely identified specimens of *Protatlanta* will settle this question.

Occurrences of some Atlanta shells unidentified:

SB 55 (2)
SB 60 (6)
SB 64 (1)
SB 68 (1)
SB 80 (1)
SB 109 (27)
SB 180 (1)
SB 181 (1)
SB 200 (2)



Text-fig. 37. *Carinaria galea* Benson. A 5.9 mm high shell from EQPH 17, ×20.

V. Records of other Heteropods, with some brief notes

11. *Carinaria galea* BENSON

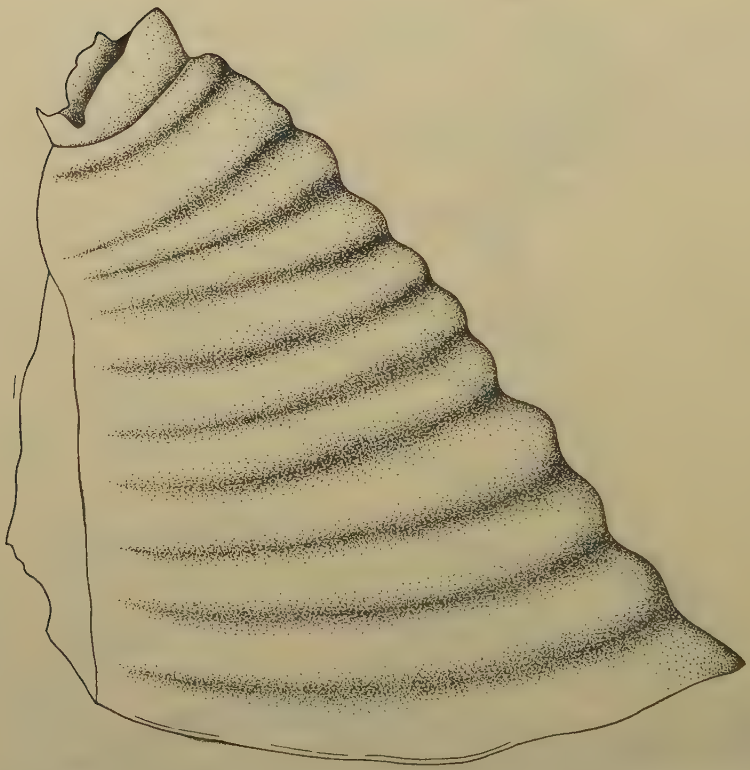
(Text-fig. 37)

A single specimen with a shell finely preserved, but had become very brittle, was found in the sample from EQPH 17. The shell is 5.9 mm high and with a very tall keel. The spire or the embryonic shell is 0.98 mm in long diameter, yellowish brown in colour, and coils three and a half times; the whorl formula is 1 : 0.47 : 0.22 as it is measured as in atlantids.

Occurrences: EQPH 11 (? 1), EQPH 17 (1)

12. *Carinaria cithara* var. *procumbens* TESCH

(Text-fig. 38)



Text-fig. 38. *Carinaria cithara* var. *procumbens* TESCH. A 2.9 mm high shell from SB 118, ×20.

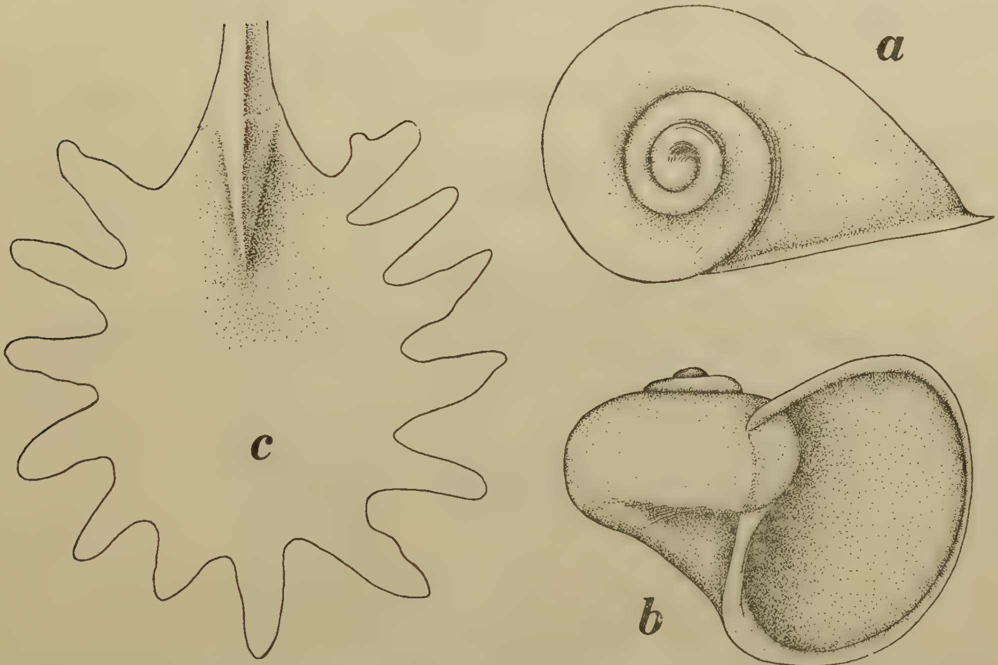
A small 2.9 mm high shell from SB 118. The embryonic shell is torn off. As the anterior side furnished with the keel is nearly straight, or rather it is slightly concave, it is very evident that this belongs to the variety *procumbens* described by TESCH (1949, p. 29).

13. *Carinaria* sp.

A single mutilated juvenile specimen from SB 20.

14. *Cardiapoda placenta* (LESSON)

(Text-fig. 39)



Text-fig. 39. *Cardiapoda placenta* LESSON from SB 125. a···apical view of shell, b···front view of shell, c···dorsal view of tail fin; ×20.

Here is described an individual from SB 125. The shell is 3 mm in long diameter and 2 mm in height. It is quite transparent and yet without any keel nor winglets described by TESCH (1949, p. 36). The umbilicus is deep. The apical side of the spire is nearly flat. The horizontal tail fin is pigmented in purplish brown.

Occurrences: SB 125 (1), SB 187 (1), EQPH 11 (4)

15. *Cardiapoda* sp.

All the specimens are in unsatisfactory condition for identification, although many of them are considered to be *C. richardi* VEYSSIÈRE.

Occurrences:

SB 55 (1)
SB 95 (1)
SB 100 (1)
SB 137 (1)
SB 150 (1)
SB 160 (2)
SB 175 (1)
SB 180 (1)
SB 210 (1)
TP 109 (1)

TP···Transpac Stations.

16. *Pterosoma planum* LESSON

Occurrences: SB 35 (1), SB 187 (1), MP 14 (1). MP···Midpac Stations.

17. *Pterotrachea coronata* FORSKÅL

Occurrences:

SB 105 (1)
SB 118 (1)
SB 181 (2)
SB 187 (2)
SB 217 (1)

18. *Pterotrachea* spp.

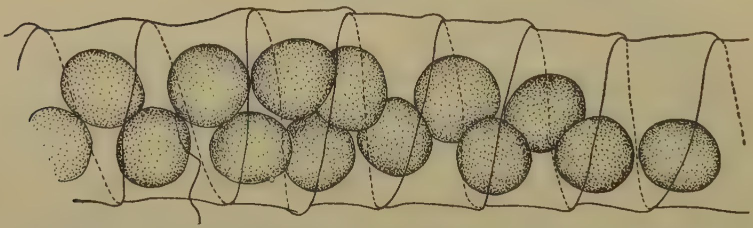
Very probably most of these mutilated juvenile specimens are belonging to *P. coronata*.

Occurrences:

SB 35 (1)
SB 80 (1)
SB 90 (1)
SB 109 (1)
SB 112 (5)
SB 142 (3)
SB 150 (1)
SB 155 (4)
SB 180 (4)
EQPH 11 (1)
EQPH 17 (9)
MP 20 (1)

19. *Firoloida desmaresti* LESUEUR

(Text-fig. 40)



Text-fig. 40. *Firoloida desmaresti* LESUEUR. A part of egg string showing the existence of a low spiral ridge winding clockwise, ×73.

Occurrences:

SB 10 (1)
SB 15 (3)
SB 30 (3)
SB 35 (1)
SB 44 (16)
SB 50 (1)
SB 55 (3)
SB 80 (2)
SB 90 (5)
SB 100 (5)
SB 105 (2)
SB 145 (2)
SB 150 (7)
SB 155 (19)
SB 160 (5)
SB 166 (6)
SB 170 (4)
SB 175 (2)
SB 180 (2)
SB 181 (10)
SB 187 (9)
SB 195 (1)
SB 200 (2)
EQPH 3 (1)
EQPH 7 (1)
EQPH 11 (5)
EQPH 17 (1)
MP 5 (1)
MP 8 (1)
MP 10 (2)
MP 10A (1)
MP 14 (28)
MP 16 (1)
MP 35 (1)

VI. Records of some Pteropods, with some brief notes.

1. *Limacina helicina* (PHIPPS)

Occurrences: TP 20 (7), TP 21 (1), TP 27 (15)

2. *Limacina trochiformis* (D'ORBIGNY)

Occurrences:

SB 80 (7)
SB 85 (1)
SB 100 (3)
SB 105 (7)
SB 109 (10)
SB 112 (1)
SB 115 (2)
SB 122 (1)
SB 130 (1)
SB 132 (5)
SB 137 (39)
SB 142 (2)
SB 145 (29)
SB 150 (8)
SB 155 (13)
SB 160 (10)
SB 180 (9)
SB 181 (64)
SB 187 (40)
SB 195 (2)
SB 200 (33)
SB 215 (2)
SB 217 (756)
EQPH 7 (1)
EQPH 11 (20)
EQPH 17 (30)

3. *Limacina inflata* (D'ORBIGNY)

Occurrences:

SB 5 (+)
BS 10 (+)
SB 15 (+)
SB 50 (4)
SB 55 (3)
SB 75 (3)
SB 80 (24)
SB 85 (1)
SB 90 (5)
SB 95 (13)
SB 100 (1)
SB 105 (1)
SB 115 (6)
SB 150 (8)
SB 155 (2)
SB 160 (51)
SB 175 (19)
SB 180 (1)
SB 181 (19)
SB 187 (94)
SB 195 (1)
SB 200 (406)
SB 215 (4)
SB 217 (1)
EQPH 3 (58)
EQPH 7 (23)
EQPH 11 (181)
EQPH 17 (8)
EQPS 28 (2)

4. *Limacina lesueuri* (d'Orbigny)

Occurrences: SB 1 (?1), SB 10 (+)

5. *Limacina bulimoides* (d'Orbigny)

Occurrences:

SB 80 (1)
SB 145 (1)
SB 160 (9)
SB 180 (4)
SB 181 (8)
SB 187 (2)
SB 200 (6)
EQPH 3 (4)
EQPH 7 (3)
EQPH 11 (44)
EQPH 17 (19)
MP 41 (2)

6. *Euclio pyramidata* (Linné)

Occurrences:

SB 10 (+)
SB 50 (3)
SB 80 (4)
SB 85 (2)
SB 90 (1)
SB 105 (2)
SB 112 (17)
SB 137 (?4)
SB 142 (3)
SB 150 (2)
SB 160 (5)
SB 181 (47)
EQPH 3 (juv. 1)
D-6-109 (Aug. 13, '49) abundant

7. *Euclio cuspidata* (Bosc)

(Text-fig. 41, *f–h*)

Embryonic shell is somewhat roundish and with a solid and acutely pointed prominence at the tip which is curved towards the dorsal side. The shell is devoid of any distinct ridges along the lateral side in younger stages and the section shows a triangular outline with rounded corners.

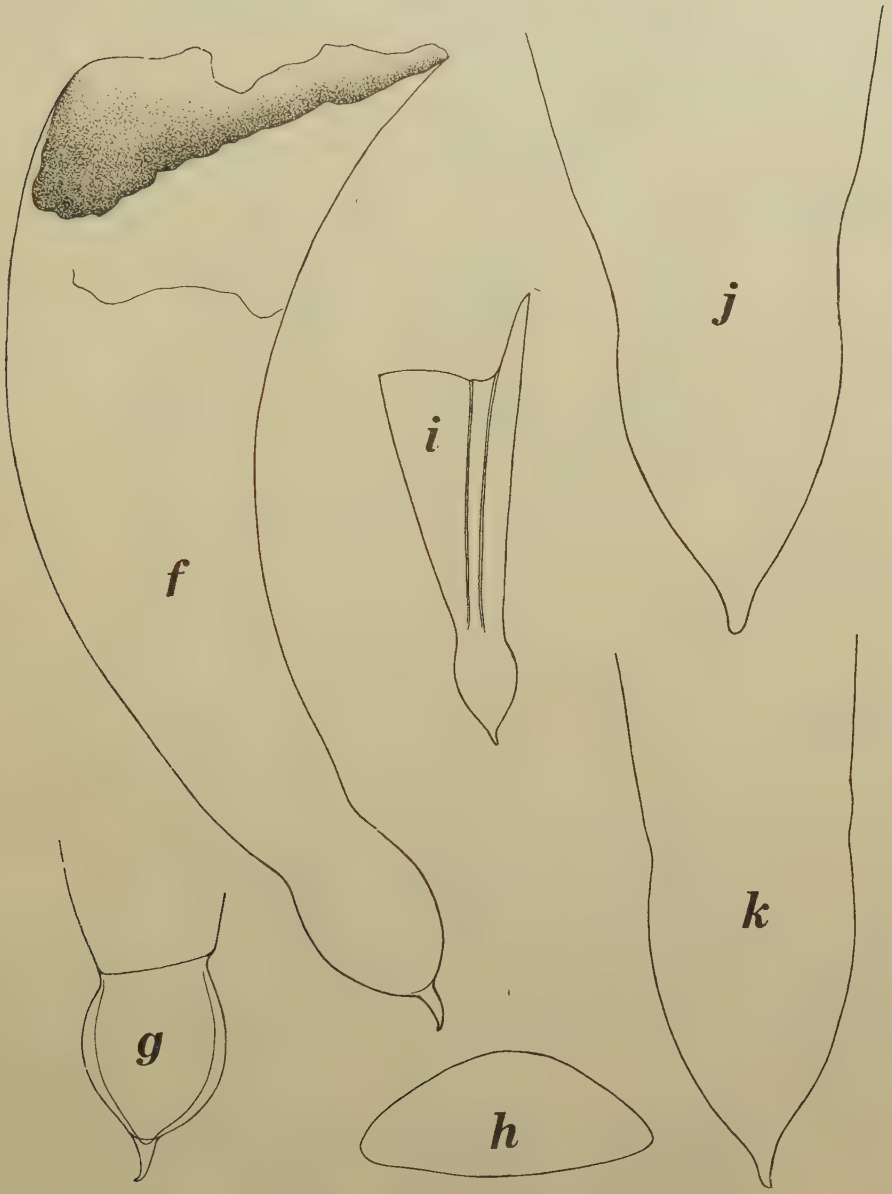
Occurrences:

SB 100 (51)
SB 105 (1)
SB 115 (2)
SB 175 (3)
SB 180 (4)
SB 187 (19)
SB 210 (2)
SB 215 (13)
EQPH 3 (1)

8. *Euclio balantium* (Rang)

(Text-fig. 41, *i–k*)

Two brownish crests on the lateral side. Embryonic shell resembles closely that of *Euclio cuspidata* in a somewhat swollen appearance with a small pointed prominence very slightly curved towards the dorsal side, but it may become like that of *Euclio pyramidata* in some adults.



Text-fig. 41. f–h. *Euclio cuspidata* (Bosc). A young shell from EQPH 3. f···lateral view of the shell, g··· embryonic shell, h···section of the shell, all ×127.

i–k. *Euclio balantium* (Rang). Young shells from SB 115. i···lateral view of the shell, j and k···embryonic shells, ×127.

Occurrences:

SB 115 (+)
SB 118 (7)
SB 122 (3)
SB 145 (2)
SB 160 (2)
EQPH 7 (5)
EQPH 11 (5)
EQPH 17 (3)

9. *Creseis acicula acicula* RANG

Occurrences:

SB 15 (+)
SB 55 (4)
SB 60 (3)
SB 64 (3)
SB 68 (1)
SB 71 (1)
SB 75 (4)
SB 80 (7)
SB 109 (2)
SB 142 (10)
SB 145 (5)
SB 155 (8)
SB 160 (45)
SB 175 (62)
SB 180 (4)
SB 181 (22)
SB 187 (10)
SB 200 (9)
SB 210 (4)
SB 217 (?1)
EQPH 7 (3)
EQPH 11 (8)
TP 74 (abundant)

9a. *Creseis acicula clava* RANG

Occurrences: SB 80 (1), SB 109 (1), SB 112 (1), EQPH 17 (2)

10. *Creseis virgula virgula* RANG

Occurrences:

SB 10 (+)
SB 50 (1)
SB 55 (5)
SB 60 (5)
SB 64 (2)
SB 68 (3)
SB 71 (6)
SB 75 (3)
SB 85 (2)
SB 90 (2)
SB 95 (1)
SB 100 (2)
SB 175 (5)
SB 210 (6)
SB 217 (7)
EQPH 7 (5)
EQPH 11 (57)
EQPH 17 (2)

10a. *Creseis virgula conica* (ESCHSCHOLTZ)

Occurrences:

SB 15 (+)
SB 68 (1)
SB 75 (2)
SB 80 (3)
SB 100 (14)
SB 105 (7)
SB 109 (14)
SB 112 (7)
SB 115 (12)
SB 118 (5)
SB 125 (2)
SB 137 (27)
SB 142 (7)
SB 145 (7)
SB 150 (8)
SB 155 (26)
SB 160 (9)
SB 175 (6)
SB 180 (11)
SB 181 (76)
SB 187 (34)
SB 195 (3)
SB 200 (39)
EQPH 3 (2)
EQPH 7 (1)
EQPH 11 (8)
EQPH 17 (9)
EQPS 28 (1)

11. *Creseis* sp.

A mutilated specimen unidentified from SB 217.

12. *Styliola subula* (Quoy et Gaimard)

Occurrences:

SB 15 (+)
EQPH 3 (25)
EQPH 7 (1)
EQPH 11 (1)
EQPH 17 (40)

13. *Hyalocylis striata* (Rang)

Occurrences:

SB 15 (+)
SB 55 (5)
SB 60 (3)
SB 68 (3)
SB 71 (6)
SB 75 (1)
SB 80 (8)
SB 112 (3)
SB 150 (?2)
SB 155 (11)
SB 160 (2)
SB 175 (14)
SB 180 (3)
SB 181 (7)
SB 187 (5)
SB 200 (7)
EQPH 3 (4)
EQPH 7 (8)
EQPH 11 (8)
EQPH 17 (1)

14. *Diacria trispinosa trispinosa* (Lesueur)

Occurrences:

SB 55 (juv. 15)
SB 125 (juv. 1)
SB 145 (juv. 1)
SB 195 (?1)
EQPH 7 (2)
EQPH 11 (juv. 4, ad. 2)
EQPH 17 (juv. 4)

15. *Diacria quadridentata quadridentata* (Lesueur)

Of the twenty shells from EQPH 11, eight were of the usual type, whitish and with some brownish flecks at some parts of the shell, while other twelve were smaller, wholly brownish in colour, and with the five longitudinal ridges on the dorsal side of the shell which were marked much more clearly; probably the latter belongs to the subspecies *costata* (Pfeffer).

Occurrences:

SB 15 (juv. +)
SB 55 (juv. 7)
SB 60 (4)
SB 64 (2)
SB 68 (juv. 1, ad. 1)
SB 75 (juv. 1)
SB 80 (juv. 1, ad. 2)
SB 100 (juv. +)
SB 142 (juv. 1)
SB 145 (juv. 3)
SB 150 (juv. 1)
SB 160 (juv. 6, ad. 10)
SB 166 (1)
SB 175 (juv. 6, ad. 7)
SB 180 (1)
SB 181 (1)
SB 187 (juv. 1)
SB 195 (1)
SB 200 (juv. 2, ad. 12)
SB 210 (juv. 2)
SB 217 (juv. 1)
EQPH 3 (2)
EQPH 7 (juv. 2, ad. 8)
EQPH 11 (juv. 5, ad. 20)
EQPH 17 (juv. 5, ad. 6)

16. *Cavolinia tridentata* FORSKÅL

Occurrences:

SB 60 (juv. 1)
SB 64 (juv. 2)
SB 80 (juv. 2)
SB 95 (juv. 4)
SB 100 (juv. 1)
SB 195 (?4)
EQPH 11 (1)
TP 81 (1, enclosed in a gelatinous envelope)

17. *Cavolinia longirostris longirostris* (LESUEUR)

Occurrences:

SB 15 (+)
SB 80 (1)
SB 109 (3)
SB 130 (1)
SB 137 (2)
SB 145 (3)
SB 150 (2)
SB 155 (1)
SB 160 (12)
SB 166 (2)
SB 187 (1)
SB 210 (1)
SB 217 (1)
EQPH 7 (juv. 3, ad. 1)
EQPH 11 (13)
EQPH 17 (8)

17a. *Cavolinia longirostris angulata* (SOULEYET)

Occurrences: EQPH 7 (1), EQPH 11 (13).

17b. *Cavolinia longirostris strangulata* HEDLEY

Three shells from EQPH 11.

18. *Cavolinia gibbosa* (RANG)

A single shell from EQPH 17.

19. *Cavolinia uncinata* (RANG)

Occurrences: SB 71 (1), SB 181 (2)

20. *Cavolinia globulosa* (RANG)

Occurrences:

SB 55 (1)
SB 100 (13)
SB 210 (1)
EQPH 11 (juv. 1, ad. 5)
EQPH 17 (juv. 1)

21. *Cavolinia inflexa* (RANG)

Occurrences:

SB 10 (juv. +)
SB 71 (juv. 1)
SB 80 (juv. 1)
SB 175 (juv. 4)
SB 200 (juv. 1)
EQPH 3 (7)
EQPH 7 (3)
EQPH 11 (juv. 4)
EQPH 17 (12)
EQPS 28 (1)

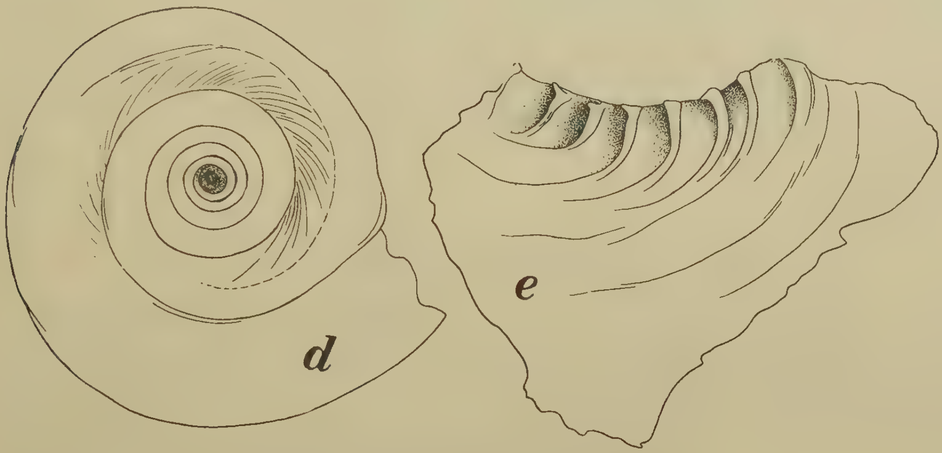
22. *Cavolinia* spp.

Mutilated and unidentified specimens occurred as SB 175 (2), SB 195 (1), and EQPH 7 (juv. 1).

23. *Peraclis reticulata* (d'ORBIGNY)

(Text-fig. 42d)

Occurrences: EQPH 7 (1), EQPH 11 (1), EQPH 17 (6), MP 41 (+)



Text-fig. 42. Operculum of *Peraclis reticulata* (d'ORBIGNY) (d, ×73) and a part of the body whorl of *Peraclis apicifulva* MEISENHEIMER showing the sculptures along the suture (e, ×127).

24. *Peraclis apicifulva* MEISENHEIMER

(Text-fig. 42e)

This species can be distinguished by the smoothly surfaced feature of the shell, which is, however, furnished with a number of short radially arranged crests found along the suture between the body whorl and the spire (Text-fig. 42e). The shell from SB 80 with a 1.1 mm long diameter and coiled two and a quarter times shows the whorl formula 1:0.30:0.10.

Occurrences: SB 80 (2)

25. *Peraclis* spp.

Mutilated and unidentified specimens occurred as:

SB 60 (1)
SB 80 (2)
SB 85 (1)
SB 100 (1)
SB 142 (1)
SB 155 (1)
SB 175 (6)
SB 181 (1)
SB 210 (2)
MP 41 (1)

26. *Cymbulia sibogae* Tesch

The dorsal part of the pseudoconcha tapers rather abruptly and in some specimens it is prolonged for a considerable length and ends acutely. The ventral part is never narrowed. The median and two ventro-lateral ridges are defined clearly on the aboral side, the former is shorter than the latter. In addition to these, one or two ridges are formed on each lateral∼latero-oral side; these and the ventro-lateral ridges on the aboral side may be forked into two branches ventrally (specimens from SB 160). And the inner branch of the oral-most ridge is often furnished with 3–4 prominent teeth along the aperture (specimens from SB 175 and EQPH 11).

Occurrences:

SB 100 (12, 18, 19 mm inds.)
SB 112 (15.5 mm ind.)
SB 115 (12.5 mm ind.)
SB 160 (24.5, 25 mm inds.)
SB 175 (18, 22 mm inds. and 3)
SB 180 (17 mm ind.)
SB 181 (28.5 mm ind.)
SB 187 (3)
SB 195 (+)
SB 200 (2)
EQPH 11 (25 mm ind. and 3)

27. *Corolla ovata* (Quoy et Gaimard)

A considerable number of pseudochonchs were found in the sample from SB 1.

28. *Corolla* sp.

Pseudochoncha is oval, rounded at both ends, and about 30 mm long and 17 mm wide. Aperture is nearly one half as long as the pseudoconcha. The distribution of spinules on the surface is very regular as is found on *Corolla* sp. from the Atlantic described by Tesch (1946; p. 38, Pl. V figs. 29 a–b). A single pseudoconch from SB 85.

29. *Desmopterus papilio* Chun

Occurrences:

SB 1 (3)
SB 25 (2)
SB 35 (1)
SB 50 (1)
SB 55 (8)
SB 60 (7)

SB 75 (1)
SP 80 (3)
SB 95 (1)
SB 112 (4)
SB 122 (1)
SB 155 (1)
SB 170 (5)
SB 180 (9)
SB 187 (6)
SB 195 (5)
SB 215 (7)
SB 217 (8)
EQPH 3 (1)
EQPH 7 (1)
EQPH 11 (10)
EQPH 17 (4)
TP 70 (1)
MP 8 (4)
MP 15 (1)
MP 20 (1)
MP 41 (1)
J 5 (1)
J 6 (2)

J…Stations in the north-eastern waters off Japan.

30. *Hydromyles globulosa* (Rang)

Occurrences: EQPH 3 (6), EQPH 7 (2)

31. *Thliptodon akatsukai* Tokioka

A single specimen from SB 50.

32. *Thliptodon* spp.

Although they can't be identified exactly on account of their so strongly contracted condition, some of large individuals (for instance, those from SB 125 and SB 132) might belong to *T. diaphanus* (Meisenheimer) and the individual from SB 130 might be *T. gegenbauri* Boas as the anterior part of the body having a pair of anterior tentacles looks like that of the species.

Occurrences:

SB 44 (1)
SB 68 (1)
SB 95 (1)
SB 105 (1)
SB 118 (1)
SB 125 (1)
SB 130 (1)
SB 132 (5)
SB 145 (1)
SB 155 (1)
SB 160 (1)
SB 180 (?1)
SB 187 (1)

33. ? *Pneumodermopsis* sp.

Occurrences: SB 64 (1), SB 130 (1), EQPH 11 (2)

34. Gymnosomata unidentified

Occurrences:

SB 30 (1)
SB 68 (1)
SB 71 (1)
SB 100 (4)
SB 142 (1)
SB 175 (1)
SB 180 (1)
SB 181 (1)
SB 195 (1)
SB 200 (5)
SB 95 (1, probably *Notobranchaea* sp.)

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Tesch, J. J. (1906): Die Heteropoden der Siboga-Expedition. Siboga-Expeditie, Monogr. 51, 112 pp., 14 pls.

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Tokioka, T. (1955 a): On some plankton animals collected by the Syunkotu-maru in May–June 1954 II. Shells of Atlantidae (Heteropoda). Publ. Seto Mar. Biol. Lab., Vol. 4, Nos. 2–3, pp. 227–236, pls. 14–16, 5 text-figs.

——— (1955 b): Shells of Atlantidae (Heteropoda) collected by the Soyo-maru in the southern waters of Japan. Ibid., pp. 237–250, Pls. 17–18, 10 text-figs.

NOTES ON THE GENUS *CARINARIA* (HETEROPODA) FROM JAPANESE AND ADJACENT WATERS

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With Plates XII–XIII and 25 Text-figures

I. Introduction

Many taxonomic papers have been published on the genus *Carinaria* of Heteropoda by Smith (1888), Tesch (1906, 1949), Bonnevie (1920), and others. However, this animal group from Japanese waters has been recorded only fragmentally to this date, although a few papers have been presented about some heteropods from Japanese waters by Tokioka (1955) and Okutani (1955a, 1957a, 1957b, 1957c).

This paper is devoted to record the occurrences of Carinarias in Japanese waters by describing the specimens found in plankton samples preserved in the Marine Resources Section of the Tokai Regional Fisheries Research Laboratory and those in the Misaki Marine Biological Station.

Thanks are due to Mr. Zinzirô Nakai of the Tokai Regional Fisheries Research Laboratory for his encouragement and suggestions rendered to the present author during the study. Many thanks are also extended to Dr. Takasi Tokioka of the Seto Marine Biological Laboratory, Kyoto University, for his kind criticism on this work as well as careful reading of the manuscript. The writer expresses his sincere gratitude to Dr. Itirô Tomiyama, the director of the Misaki Marine Biological Station, the late Dr. Isao Taki of the National Science Museum, Dr. John A. McGowan of the Scripps Institution of Oceanography, Dr. Masuoki Horikoshi of the Ochanomizu University, Mr. Yôji Kurata of the Tokyo Fisheries Experimental Station and Messrs. Korokurô Nakamigawa and Akibumi Teramachi of the Malacological Society of Japan for their kindness in giving the writer various facilities. Thanks are also due to the crew of the survey vessels who cooperated in collecting the most important part of the material dealt with in this study.

Publl. Seto Mar. Biol. Lab., IX (2), 1961. (Article 16)

II. Systematic Account

Heteropoda: Family Carinariidae

For the convenience of becoming familiar to this animal group, the characteristics of animals of the genus *Carinaria* are redescribed here by summing up criteria given by previous authors.

Genus *Carinaria*, LAMARCK 1801, Syst. Anim., p. 98

Type species: *Carinaria vitrea* Làmarck (=*Patella cristata* LINNÉ)

Body cylindrical in shape, translucent as it is thickly covered with translucent, gelatinous cutis throughout, proboscis thick; tail laterally compressed and usually with a tail-crest on the dorsal side, pointed at the posterior tip. Eye with triangular or cylindrical base; a pair of cephalic tentacle in front of eye, the right one frequently vestigial or absent.

Visceral nucleus on the dorsal side approximately at the middle of the entire body, apparently pedunculated, covered by a capuliform shell. Ctenidia projecting a little beyond the anterior edge of the free margin of mantle.

Musculature distinct through the cutis; muscle bands of trunk generally oblique, while those of posterior part of body and tail longitudinal, divided into several stripes on the latter. The dorsal-most muscle band of tail issues a number of delicate muscle threads radially into the crest.

Swimming fin located nearly opposite the nucleus, usually semicircular or quadrilateral in outline, with a network of regularly crossing muscle fibers; sucker without a stalk, situated on the ventro-posterior margin of fin in both sexes. Cutis generally colorless, studded with gelatinous tubercles.

Shell with a carina on the anterior margin and a number of transverse ribs on the lateral side; sperture nearly subovoid, longer than broad; larval shell helicinoid, preserved in adult.

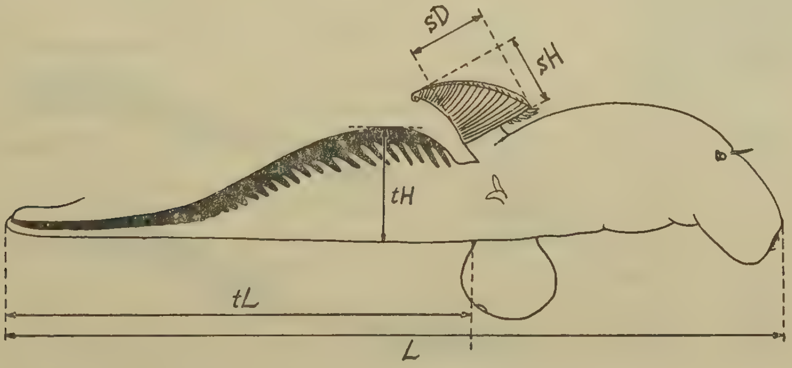
Radular formula 2-1-C-1-2; the rhachidian tooth usually depressed trapezoid in shape, with 3 cusps at the tip; both marginals nearly equal in shape and size, sickle-shaped and pointed at the tip; lateral oblong, with a small crest and a shallow dentation on the free margin; jaw plate shield-shape, elastic.

As the specimens are easily deformed by fixation, specific characters are rather subtle excepting the shell which is, however, very frequently found destroyed. That is why a great number of species had been described under different trivial names until TESCH (1949) made a thoroughful criticism on the validity of various works prior to him and rearranged them.

In the present descriptions, the following measurement (Text-fig. 1) are given on every specimen.

L : Entire length from the anterior tip of the proboscis extended in natural condition to the posterior tip of the tail, but excluding the tail filament.
sH : Shell height; the heighest part of the shell standing on the aperture; the height of the nucleus is measured in place of sH when the shell is lost.
sD : The major diameter of the shell aperture.
tL : Tail length from the posterior margin of the base of the swimming fin to the posterior tip of the tail.
tH : Tail height from the ventral side to the crest margin at the highest part of the dorsal crest.

In addition, body height, length of the eye including both the lens and basal part, eye diameter and ratios between these measurements are occasionally taken into consideration.



Text-figure 1. Diagram showing various measurements referred. L: entire length, sH: shell height, sD: major diameter of the aperture, tL: tail length, tH: tail height.

1. *Carinaria cristata* (Linné, 1766)

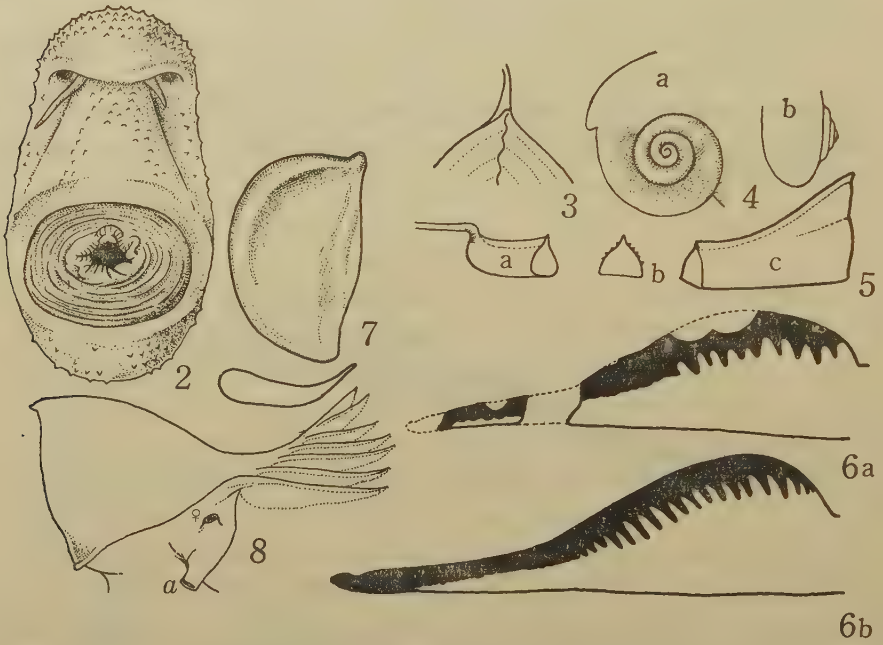
(Text-figs. 2–8; Pl. XII, figs. 1–4; Pl. XIII, fig. 1)

Carinaria vitrea, Reeve, 1865, vol. xv, pl. 1, figs. 2a–b;
Carinaria cristata, E. A. Smith, 1888, p. 30, figs. 3a–b, 4a–b;
Carinaria cristata, Tesch, 1906, p. 65, pl. 9, figs. 35–42; pl 10, fig. 43;
Carinaria cristata, Thiele, 1929, p. 257;
Carinaria cristata, Tesch, 1949, p. 28, pl. 2, figs. 3A–D;
Carinaria cristata, Tokioka, 1951, p. 1134, fig. 3223;
Carinaria cristata, Taki, 1954, pl. 129, fig. 1.

Body attains more than 500 mm in entire length (L); dorsum of the trunk conspicuosly elevated, height reaching 16% to L in adult; tail-crest semi-circular in outline, tH generally 20–26% to tL, and with the dorsal margin sharply edged

(Text-fig. 5); the posterior part of the crest is gently sloping down posteriorly and tapering to a whip-like prolongation with a nearly triangle cross-section; a dark-colored short filament follows the prolongation, 30 mm in length in a 240 mm long specimen.

Eye relatively small, dark in color, with the triangular retinal part broadly-based; a pair of cephalic tentacle in from of eyes, sometimes hidden in the transverse groove frequently observed on the brow of full-grown specimens, right one sometimes smaller than the left (Text-fig. 2), for example, right 6 mm and left 16 mm in a 340 mm-specimen.



Text-figures 2–8. *Carinaria cristata* (LINNÉ)

2. Frontal view, showing the cephalic tentacles of different length; 388 mm long specimen from Koajiro Cove, Sagami Bay.
3. Carina of shell, apertural view; 501 mm long individual from Sagami Bay.
4. Protoconch, 1.15×0.9 mm; from Tosa Bay, sH=22.6 mm.
5. Diagram showing the shape of the posterior part of tail.
6. Two types of color-pattern of tail; a. 210 mm long injured specimen; b. 340 mm long injured individual.
7. Jaw plate of a full-grown specimen.
8. Anus and genital opening of the 430 mm long injured female from Misaki.
   a: anus, ♀: genital opening.

Shell highly elevated, curved backwards; sH about 80% to sD; carina about 7% as wide as sD, consisting of two lamellae spaced by an extremely narrow slit and slightly inclined to the right side (Text-fig. 3).

Cutis covered with many variously sized gelatinous tubercles all over the surface, most densely on the dorsum, but rather sparsely on the ventral side. The body usually milky white in young specimens, but often faintly purplish on the dorsal side; the dorsal half of the tail-crest dark reddish purple or burgundy, but usually sprinkled with white spots formed by large-sized mamillar tubercles; the ventral margin of this colored area is asymmetrically undulating (Text-fig. 6).

Table 1. Data of examined *C. cristata* (L.).

Locality		Date	Sex	L (mm)	sH (mm)	sH/sD	tH/tL
Lat. N Long. E							
Koajiro Cove, Miura Peninsula	(Misaki MBS)	Aug. 26, '36	♀	430*	—	—	0.18
Koajiro Cove, Miura Peninsula	(»)	»	♂	388	—	—	0.36
Neighbourhood of Misaki MBS	(»)	—	♂	500	—	—	0.26
Araihama Beach, Miura Peninsula	(»)	Jan., '56	♀	160*	—	—	—
Moroiso Cove, Miura Peninsula	(Mr. HAMASAKI)	Dec. 23, '57	♀	340*	—	—	0.26
Maehama Beach, Niijima Isl.	(Mr. KURATA)	Mar. 8, '58	♀	340*	—	—	—
Moroiso Cove, Miura Peninsula	(Dr. HORIKOSHI)	Oct. 12, '58	♀	210	—	—	—
Najima, Sagami Bay	(Misaki MBS)	Mar., '59	♀	501	56	0.82	0.20
Kasajima, Sagami Bay	(Mr. NAKAMIGAWA)	May 11, '59	♂	240	35	0.95	0.33
Tôshiki Beach, Ôshima Isl.	(Mr. KURATA)	July 26, '61	—	140*	—	—	—
Off Nomashi, Ôshima Isl.	(Mr. KURATA)	Apr. 24, '61	—	58*	—	—	—
Tosa Bay	(Mr. TERAMACHI)	—	—	—	22.6	0.77	—
35°07.2 139°34.2	(Sôyô St. U3)	Dec. 7, '59	♀	—	—	—	—
34°06.7 136°51.8	(Sôyô St. 135)	Feb. 24, '61	♀	68	13.0	1.00	0.47

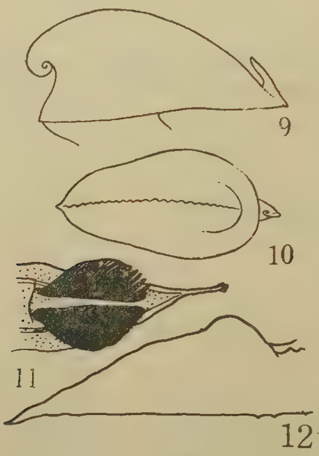
* Astrisk show the specimen measured in somewhat injured state.

2. *Carinaria lamarcki* (PÉRON et LESUEUR, 1810)

(Text-fig. 9, 10 and 12; Pl. XIII, figs. 3, 6)

Carinaria fragilis, REEVE, 1865, vol. xv, pl. 1, figs. 1a–b;
Carinaria lamarckii E. A. SMITH, 1888, p. 32;
Carinaria cymbium, WOODWARD, 1890, p. 202, fig. 66;
Carinaria australis, VAYSSIÈRE, 1904, p. 22, pl. 1, figs. 11–16;
Carinaria mediterranea, VAYSSIÈRE, 1904, p. 11, pl. 1, figs. 1–10; pl. 2, fig. 17;
Carinaria mediterranea, PELSENEER, 1906, p. 162, fig. 142;
Carinaria mediterranea var. *oceanica*, VAYSSIÈRE, 1904, p. 17, pl. 4, figs. 51–53;
Carinaria lamarcki, BONNEVIE, 1920, p. 6;
Carinaria lamarcki, TESCH, 1949, p. 26, pl. 1, fig. 1.

The largest specimen in the present material measured only 30 mm in L, although TESCH (1949) stated that specimens from the Mediterranean Sea attained 220 mm; tail-crest abruptly increases the height at the proximal one third (Text-fig. 12), not so rounded in outline as in the forgoing species, and without any distal prolongation; tH 25% to tL. Cephalic tentacles long, the right one longer than the left. Shell much depressed, apex conspicuously involute, sH 50% to sD in fully grown specimen (after Reeve, 1865). Cutis covered sparsely with large tubercles all over the surface.



Text-figures 9, 10, 12. *Carinaria lamarcki* Péron et Lesueur

9. Outline of visceral nucleus; a specimen from Naples, preserved in Tokyo University.
10. Apertural view of a full-grown shell (after Reeve, 1865).
12. Tail; a 25 mm long individual from the station 30°38′.9 N, 131°23′.8 E.

Text-figure 11. *Carinaria lamarcki challengeri* Bonnevie, ventral view of the "clasper"; a 15 mm long specimen from the station 34°18′ N, 140°56′ E.

Table 2. Data of examined *C. lamarcki* (Péron et Lesueur).

Locality			Date	Time	Layer (m)	Sex	L (mm)	sH (mm)	tH/tL
Lat. N	Long. E								
30°38.9	131°23.8	(Sôyô St. 70)	Feb. 18, '52	1839	0	♀	25	—	0.20
43°00.0	160°00.0	(Tenyô St. F1)	Aug. 3, '55	0715	0–25	—	19	—	0.23
32°11.5	139°51.0	(Sôyô St. 25)	Jun. 28, '56	0000	0–150	—	6.6	—	—
32°46.3	133°08.8	(Sôyô St. 32)	Feb. 10, '57	2107	0	—	30	3	0.40
Isl. Hachijô (Mr. Kurata)			Mar. 17, '55	—	0	—	-	—	—

3. *Carinaria lamarcki challengeri* Bonnevie, 1920

(Text-fig. 11; Pl. XIII, fig. 8)

Carinaria lamarcki (part?) E. A. Smith, 1888, p. 37;
Carinaria poseudo-rugosa (part) Vayassière, 1904, p. 20, pl. 6, figs. 82–5;
Carinaria lamarcki var. *challengeri* Bonnevie, 1920, p. 6, pl. 2, figs. 16–25.

Body up to 15 mm in L; dorsum remarkably elevated; tail-crest much depressed; eye small; left cephalic tentacle long but hidden in the transverse groove on the brow, the right one absent; a dark colored appendage—clasper by Bonnevie (1920) on the ventral side of tail (Text-fig. 11); cutis wholly punctate.

Table 3. Data of examined *C. lamarcki challengeri* Bonnevie.

Locality			Date	Time	Layer (m)	Sex	L (mm)	sH	tH/tL
Sat. N	Long. E								
34°18.0	140°56.0	(Meiyô St. C53)	Mar. 26, '58	1730	0	♀	15	—	—
32°23.0	135°51.0	(No. 2 Kuroshio St. 6)	Dec. 8, '59	1750	0	♂	15	—	—
33°08.0	140°00.0	(Sôyô St. B3)	Mar. 3, '60	2142	0	♀	11	—	—
The Sea off Enshu-Nada			—	—	0	♀	20	—	—

Remarks: Various forms of *C. lamarcki* (Péron et Lesueur) has been described from different localities of the world seas. Especially, Bonnevie (1920) described a well-defined small form trom Gibralter and African waters which is only 30–40 mm in entire length. Although her specimens were at first considered to be a juvenile of a known species, she showed by histological examination that the gonads of the specimens were already matured. Moreover, the specimens were distantly characterized by having the "clasper" consisting of a pair of darkly pigmented folds on the postero-ventral side of the body. This organ is not found on any other forms including the typical *lamarcki* in the present material. No comprehensive works have been made on this "clasper" until to-day, but it is very interesting to state here that the similar black organ is observed on other Carinarid animal, *Cardiopoda richardi* (Vayssière).

4. *Carinaria* (*cristata* var.?) *japonica* Okutani, 1955

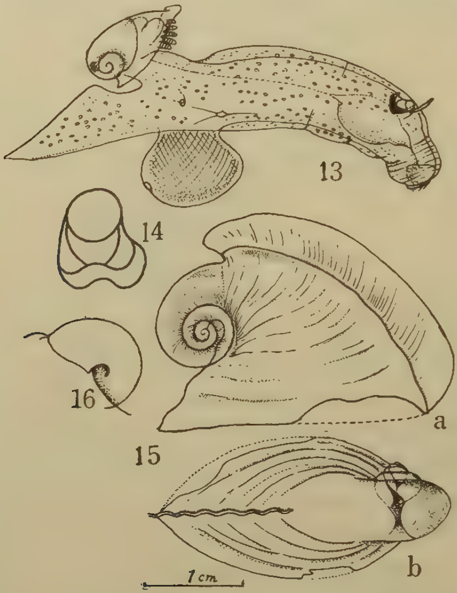
(Text-figs. 13–16; Pl. XIII; figs. 2, 7)

Carinaria lamarcki, Dales 1952, p. 1110, fig. 4 (non Péron et Lesueur);
Carinaria japonica, Okutani 1955, p. 251, figs. 1–3.

Body attains 62 mm in L; tail-crest conspicuously elevated nearly to the level of the tip of the nucleus, triangle in outline, tH 43–53% to tL; eye with the broardly based and traianglar retinal part (Text-fig. 14); the right cephalic tentacle slightly shorter than the left, although both tentacles may often be of equal length.

Shell moderately elevated, sH 80–100% to sD; nuclear whorl coils 4 times and marked with very fine striae on the surface, umbilicus very narrow, faintly yellow; post-nuclear parts translucent, width of carina 15% to sD (Text-figs. 15, 16). Cutis smooth with several gelatinous tubercles on the ventrolateral area of trunk.

Rhachidian depressed trapezoid in shape, with 3 very slender acute cusps on the tip; laterals oblong and with a sharp crest on the free margin; 2 marginals sickle shaped sharply pointed at the tip; on a 34 mm-long specimen rachidian 0.75 mm in width, lateral 0.45 mm long and 0.15 mm wide, marginal 0.50 mm in length.



Text-figures 13–16. *Carinaria* (*cristata* var. ?) *japonica* OKUTANI.

13. A 14.5 mm long individual from the station 43° N, 179° E.
14. Eye of the same specimen, dorsal view.
15. Shell of an individual from the station 43°02′N, 176° E; sH=2.0 mm.
16. Umibilicus of the same shell.

Table 4. Data of examined *C. japonica* OKUTANI.

Locality			Date	Time	Layer (m)	Sex	L (mm)	sH (mm)	sH/sD	tH/tL
Lat. N	Long. E									
44°11.0	159°30.0	(Kôyô St. 20)	Aug. 7, '54	0820	0	—	19	—	—	—
*36°21.0	141°00.0	(Heiwa-Ibaraki St. 5)	Jun. 29, '55	1340	0–150	♀	62	—	—	0.43
43°48.0	164°38.5	(Sôyô St. 38)	Sep. 6, '58	1827	50	♀	28	4.5	1.12	0.43
41°00.0	175°00(W)	(Sôyô St. 25′)	Aug. 21, '58	1840	0–150	♀	62	6.5	0.93	0.51
Off Kinkazan		(Tokiwa St. 14)	Jul. 24, '59	1005	0	♀	60	—	—	—

* Holotype, stored in the Tokai Reg. Fisher. Res. Lab., Tokyo.

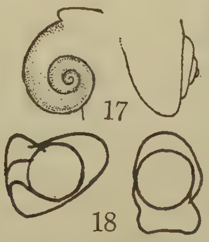
Besides the specimens shown in the above table, a great number of specimens of various stages were collected at some of the serial stations along the latitude of 43° N, the data of which is given in Chapter V where the distribution of the genus is discussed.

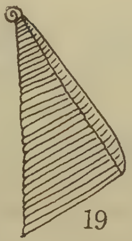
5. *Carinaria galea* BENSON, 1835

(Text-figs. 17, 18; Pl. XIV, figs. 4, 5)

Carinaria galea E. A. SMITH, 1888, p. 35;
Carinaria galea TESCH 1906, p. 71, pl. 10, figs. 44, 45;
Carinaria galea TESCH 1949, p. 27, pl. 1, figs. 2.

Body attains 42 mm in L, rather slender; tail short, tail-crest much depressed, tH 60% to tL; cutis quite transparent, furnished with large gelatinous tubercles distributed sparcely all over the surface. Eye darkly colored, retinal part with narrow base (Text-fig. 18); right tentacle vestigial.





Text-figures 17, 18. *Carinaria galea* BENSON.

17. Protoconch of an Individual from Tosa Bay, 1.3 ×1.2 mm; sH=13.2 mm.
18. Eye of the same specimen.

Text-figure 19. *Carinaria cithara* BENSON, shell (after TESCH, 1949).

Shell elevatrd, curved backward, sH larger than sD; carina enormously high, its width attaining nearly 25% to sD; protoconch slightly inclinated (Text-fig. 17).

Table 5. Data of examined *C. galea* BENSON.

Locality			Date	Time	Layer (m)	Sex	L (mm)	sH (mm)	sH/sD	tH/tL
Lat. N	Long. E									
30°49.3	140°48.3	(Sôyô St. B5)	Sep. 11, '57	—	0	♀	21	5.0	1.0	0.6
35°25.0	142°29.0	(Sôyô St. 43a)	Sep. 12, '58	1838	0	♂	49	11.2	1.25	0.6
35°35.9	137°05.0	(Sôyô St. 133)	Feb. 23, '61	1938	0	♀	46	17.5	0.86	0.6
Tosa Bay		(Mr. TERAMACHI)	—	—	—	—	—	13.2	1.37	—

6. Other species hitherto known but not found in the present material

Carinaria cithara Benson, 1835.
Carinaria cithara procumbens Tesch, 1949.

The above-mentioned two forms were not found in the present material as they are likely to be distributed in the tropical waters. These forms are small ones attaining only 50 mm in L at the maximum and distinctly characterized ay thəir much elevated shell with sH about two times sD (Tesch, 1949). Tesch's extremely rare subspecies, *procumbens* is differentiated from the typical form in having the shell bending anteriorly; this feature is quite unique as the shell is generally curved backward in other forms of the genus.

III. Interspecific Relationship

Species of the genus *Carinaria* are considered to be divided into two groups characterized by structures of eye and protoconch, which might deserve to be treated as subgenera. One of them comprises *cristata*, *lamarcki*, *japonica* and *galea* posessing each the triangular retinal part and nearly smoothly surfaced protoconch. The other is represented by a single species, *cithara*, with cylindrical eyes and protoconch ornamented with apiral lines on the surface.

Juvenile specimens of three species, *cristata*, *japonica* and *lamarcki* are hardly distinguished from each other because of close morphological resembalance in details. In this respect, Tesch (1949, p. 26) stated, "it is not always possible to identify a mass of such small Carinariae with absolute certainty, when, as is frequently the case, the shell is absent; and only an experienced eye can tell specific differences which are hardly fit to be put in words." However, young specimens of *lamarcki* seem to have retinal parts proportionally broarder than in juveniles of *japonica* in the same body length as is show below:

	L	Length of eye including retina	Diameter of retina
lamarcki	25 mm	0.63 mm	1.08 mm
japonica	26	0.63	0.63
lamarcki	11	0.55	1.00
japonica	9	0.47	0.47

Furthermore, it is noteworthy that juveniles of *cristata* resemble strikingly those of *japonica*, although the former can be distinguished by the existence of dorsal tubercles even in immature states and by low and more rounded dorsal-crest as Tesch already showed (1949, p. 25 & pl. 2, fig. 3C). The ratio between sH and sD may be useful to identify immature specimens of these two species. As none of the immature specimens of *cristata* was found in the present material, the ratio was estimated here on the measurements made by retracing growth lines on the mature shell.

	sD	sH	sD/sH
cristata	2.6 mm	2.6 mm	1.00
japonica	2.6	1.7	0.65

Morphological similarities between juvenile *cristata* and *japonica* seem to suggest that the latter might be a local form of the former confined to the northern Pacific.*

Adults of species of the genus, *Carinaria* are easily distinguished by the characters shown below.

Table 6. Shell characters of five species of *Carinaria*.

	General appearance	Protoconch	sH(max.)	sH/sD
cristata	Elevated, top curves backwards.	Helicinoid, faintly yellowish	56 mm	0.7–0.8
lamarcki	Depressed, top conspicucusly involutes.	Helicinoid	41	0.5
japonica	Elevated, top curves backwards.	Helicinoid, with fine growth striae	6.5	0.8–1.0
galea	Elevated, top curves backwards, carina very high.	Helicinoid, inclinated	13.2	1.0–1.4
cithara	Highly erected; in *procumbens* anterior edge concave.	Situating at the top, with spiral lines.	11	2.0

Table 7. Characters of soft body parts of five species of *Carinaria*.

	Eye	Dorsal-crest	L (max.)	Tubercles
cristata	Triangular, with broad base	Semi-circular; with tapering whip-like prolongation at the end.	500 mm	Very densely on the whole surface
lamarcki	"	Depressed	220**	Large, on the whorl surface
lamarcki challengeri	"	Much depressed	30	Inconspicuous
japonica	"	Elevated, triangular	62	Only on the ventrolateral part
galea	Triangular, with narrow base	Not prominent	49	Sparsely on the whole surface
cithara	Cylindrical	Not prominent	50	Sparsely

---

* Although the Mediterranean forms may grow up such a large size (TESCH 1949, p. 27), the Indo-Pacific specimens are always as small as shown in the present material. This reveals that at least two local forms are differentiated in this species.

** In this respect, Dr. T. TOKIOKA thinks that *japonica* may be a form of *lamarcki* rather than that of *cristata*. For this reason he points out that *japonica* may differ from *cristata* in shape of tail and proportion of tail and trunk as well as in feature of carina (personal communication).

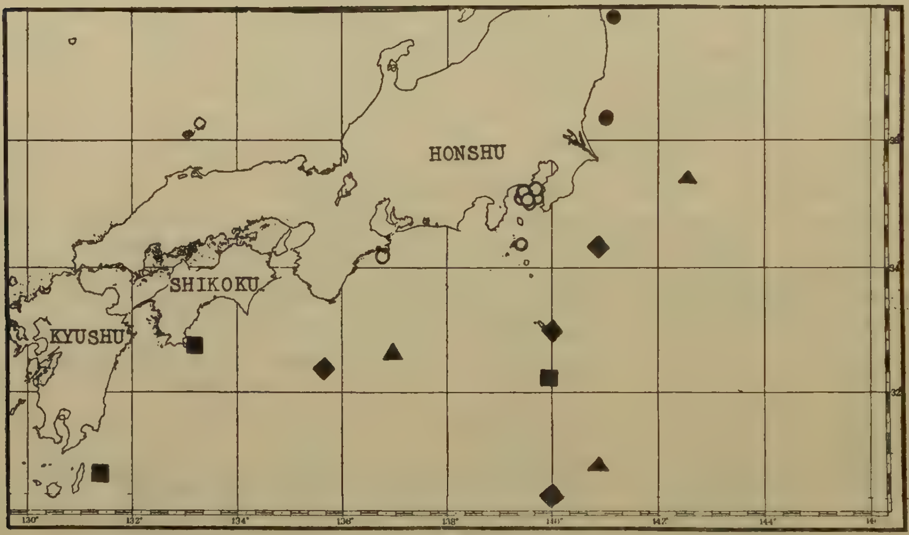
IV. Distributional Account

1. *Geographical distribution, with special reference to the occurrence of C. japonica in the eastern waters off Japan.*

Heteropods are the inhabitants of the warm waters of the world; all the species are known from the Indo-Pacific, but some are lacking in the Atlantic as the following table given by TESCH (1949, p. 49) shows clearly.

Table 8. Distribution of *Carinaria* in the world seas (modified from TESCH 1949).

	Atlantic Ocean	Indian Ocean	Pacific Ocean		Mediterranean Sea
			Tropical	Temperate	
cristata	—	×	×	×	—
lamarcki	×	×	×	×	×
lamarcki challengeri	×	×	?	×	×
japonica	—	—	—	×	—
galea	—	×	×	×	—
cithara	—	×	×	—	—

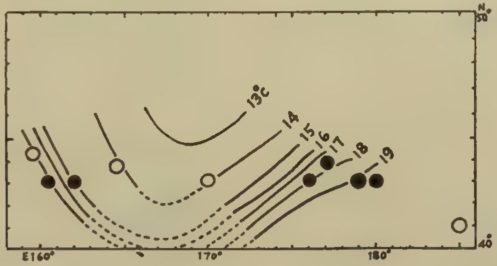


Text-figure 20. Distributional map of Carinarian species in Japanese waters.
○: *C. cristata*, ■: *C. lamarcki*, □: *C. lamarcki challengeri* ●: *C. japonica*, ▲: *C. galea.*

Generally speaking, in the Pacific, neither peculiar specific distributions nor peculiar distributional areas are conceivable, although some species show the trend to the tropical region and quite unseen in Japanese waters. In Japanese water Carinariae are usually collected in the Kuroshio area, sometimes by plankton-net or found stranded. As is shown in text-figure 20, the stations of occurrence are found along the Kuroshio or in the area generally with surface water temperature of 20°C or thereabout. *Carinaria* may sometimes be found accumulated in a great number together with other plankters along the boundary between different waters, as is seen along the polar-front of the Kuroshio.

For instance, a considerable number of *Carinaria* were collectedby the R. V. *Tenyô-Maru* during her cruise in the summer 1955. They were collected at or near the serial stations along the latitude of 43° N. Although most of them were very young and some were coiled, they were identified as *C. japonica* after the close comparative studies arranging the specimens in the order of the size. And this cleared a part of the early larval stages of this species as is mentioned later in this paper.

According to Okutani (1957 b), the lowest water temperature estimated for the occurrence of *Atlanta* (probably *lesueuri*) was 160°C. And some workers seem to consider that no heteropods inhabit in the northern part of the North Pacific. However, the oceanographic data of the R. V. *Tenyô-Maru* in the summer 1955 lowered the lower critical water temperature for the occurrence of *Carinaria* to 15°C or even below it. (Text-fig. 21).



Text-figure 21. Occurrence of *Carinaria japonica* in the polar front area of the Kuroshio; solid circle shows the station where this species was collected in 1955; open circles shows that in other years; isotherms are for the summer 1955.

In this polar front area of the Kuroshio are freqently met with other large sized plankton such as *Janthina*, *Velella* etc. which are always found in a full-grown stage. This seems to show that these animals are bred in the more southern warm water area and drifted to there by the current. On the contrary, *C. japonica* is considered to be propagating in the area surveyed by the *Tenyô-Maru*, as very early stages were found there in quantity. Anyhow it is evident that this species is distributed more northerly in the colder water than any other species of the genus. This seems to be supported by Dales (1952) who found a plenty of specimens probably belonging to this form from Californian waters where other heteropods were relatively scarce.

2. *Possible diurnal vertical migration.*

As has been cleared by the present author (1957 a, 1957 b), pteropodan and heteropodan faunas on the sea surface are completely changed by sun-set and sun-rise. Most of the specimens collected by the plankton net with a 130 cm diameter were fished by surface towing, and only two in the present material were collected at 25 m and another at 50 m layer by mid-layer horizontal haul. However, as the majority of them were got at night (from 18.00 to 06.00) and some Pterotracheas are known from the mid-layer between 256 and 600 m deep in daytime (OKUTANI, 1957 c), it is very possible that Carinarias do the diurnal vertical movement to some extent.

Table 9. Data of *C. japonica* from the polar-front area of the Kuroshio in the summer 1955.

St. No.	Lat. N	Long. E	Date (1955)	Time	Layer (m)	Num. Spec.	Sex ratio	L (range) in mm
12	43°00	160°01.5	Aug. 3	0135–40	0	5	?	17–20
13	43°00	162°00	" 3	0813–18	0	18	♀15, ♂3	12–44(sH 5.5–5.6 for L 35–37)
20	43°02	176°00	" 6	2254	0–150	2	?	2.8, 3.0
20	43°02	176°00	" "	0020–25	0	ca. 1000	?	1.2×1.9–0.6×1.0*
21a	43°00	179°00	" 7	1620–25	0	60 1	? ♂	4–39 61
22	43°00	180°00	" "	2018–23	0	15	—	8–15
22	"	"	" 8	0530	0–25	1	♂	59
23	43°57	177°30	" "	1621–26	0	2	♂2	15, 18

* Height × diameter is given on these coiled specimens.

V. Ecological Account

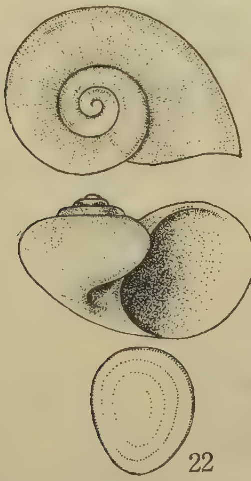
1 *An aspect of larval history*:

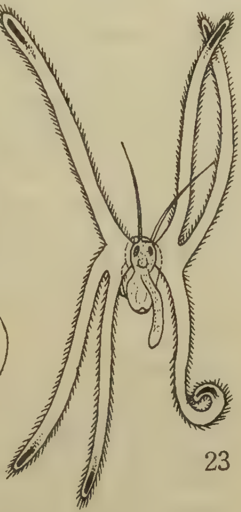
The male copulatory organ of *C. cristata* is situated on the right side of the trunk just below the visceral-nucleus. As was illustrated by TESCH (1906, pl. 9, fig. 34), the penis recurves a little, have the seminal groove and is accompanied with "Haftapparat" on its side. The female genital pore is a tiny opening adjoining to the anus (Text-fig. 8). In spite of the existance of such copulatory structures, no one has ever observed the copulatory behaviour of Carinarias. BONNEVIE (1920) found that *Carinaria lamarcki challengeri* posseses a "clasper" which is a darkly pigmented organ on the postero-ventral side of the animal, but it is hardly possible that the animal may "clasp" the mate with this organ.

Few informations have been available on the larval shells of Carinarias. Recently, however, FRANC (1949) described living larval specimens of various heteropods including *C. "mediterranea"* whose veliger is remarkable in having a very extensive velum as is seen in the reproduction of his figure (Text-fig. 23). He showed also that *C. "mediterranea"* is provided with eyes having the characteristic triangular base, this feature was observed on the specimens collected by the *R. V. Tenyô-Maru*, too.

Next, a young specimen of *C. japonica* found coiled in about 1.4 mm diameter and with 0.75 mm height is described:

> Shell of right-handed, helicinoid, very thin, transparent, entirely yellowish in color, polished and entirely with extremely fine growth lines; whorls $3\frac{1}{2}-3\frac{2}{3}$; spire rapidly increasing diameter to the aperture; the lower part of body-whorly more inflated than the upper; operture ovate; umbilicus narrow but distinct; operculum as large as aperture, horny with a few concentric lines, transparent; animal can be wholly withdrawn inside the shell (Text-fig. 22).





Text-figure 22. Larval shell and operculum of *C. japonica* from St. 20 of the *Tenyo-maru*, collected on Aug. 6, 1955.

Text-figure 23. Veliger of *C. "mediterranea"* from the Mediterranen Sea (after FRANC, 1949).

This structure of the shell agrees well with that of the protoconch preserved at the tip of the adult sgell. Slight inclination of the protoconch is responsible for the oblique appearance of the aperture lips in the coiling stage. Shell metamorphoses to a capuliform one with developmental stages. The boundary between the coiled and capuliform parts is quite distinct. In a stage with sH 1.8 mm and sD 2.3 mm, there are only 4 transverse ribs on the shell and the keel is 0.8 mm wide; the animal then attains 14.5 mm in L and yet the triangular tailcrest is differentiated already (Text-fig. 13).

2. *Feeding habit*:

Tesch (1949, pp. 50–51) found that fragments of Ctenophores, Salpae and pelagic Hyperiidae, such as *Phronima*, were spread upon the radula hooks of heteropods or remained in the gizzard. There were reportedly found mostly unidentifiable detritus, but sometimes fragments of Euphausids and even of other heteropods. He also guessed that the fish larvae might often be preyed by rapacious Carinarias and Pterotracheas. Graham (1955) stated that *Carinaria* feeds on fish, scyphozoan medusae and crustaceans. And it must be necessary to introduce here that *Carinaria* is regarded as a predator of the eggs of a sardine, *Sardinops ocellata* (Fish. Biol. Br., FAO, 1959).

Of the present material, two samples of food contents in the alimentary canal were examined. These contents were offered to Mr. K. Honjo of our Laboratory who identified them so kindly for the writer. Here the writer wants to express his hearty thanks for Mr. Honjo's kind help.

(i) Food contents of a 44 mm long female *Carinaria japonica* from St. 13 of the *Tenyô-Maru*

Euphausid larvae	6
Paracalanus parvus	1
Calanus sp.	1
Oithona pulmifera	1
Amphipoda juvenile	1
Evadne sp.	1
Sagitta bedoti	1
Thalassiothrix longissima	plenty

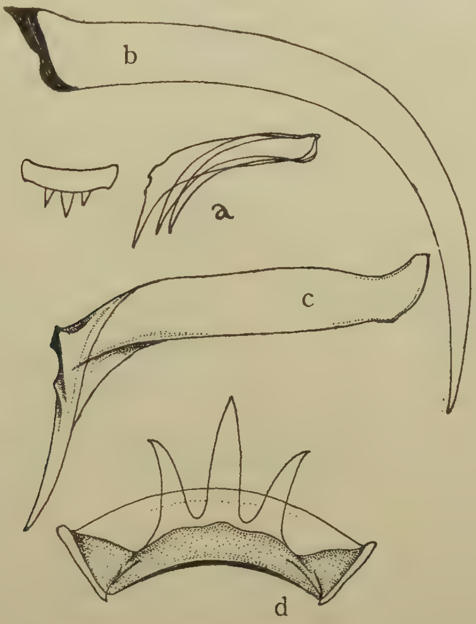
(ii) The same of a 17 mm individual from St. 12 of the *Tenyô-Maru*

Euphausid larvae	1
Crustacean remains	many

The above mentioned results seem to show that Carinarias feed on the plankton organisms *in situ*. Here it is very questionable that Carinarias take diatoms as food, although the alimentary canal of Carinarias contains some diatoms occurring in the same area. Rather it is impossible that Carinarias can take diatoms with radula, most probably these vegetable substances are brought in with salps which apparently feed on diatoms and then are preyed by heteropods. The fact that heteropods are occasionally collected together with a large number of Salps were already noted by Dales (1952, p. 1013).

Carinaria has very acute radulae, the formula of which is given in Chapter II (p. 88). Every tooth is sharply pointed at the tip (Text-fig. 24) and sickle shaped marginals are very effective to hook preys and usually peeping out of the mouth. One of the radular ribbons examined during the present study was found provided with 60 rows of radulae. The present author observed once on board the R. V. *Sôyô-Maru* that the animal occassionally extended the proboscis straightly and some food particles jiggling in the gizzard were distinctly observable through the cutis.

The coloration of the gizzard and oesophagus of living animals is apparently caused by food organisms. Some examples of colorations of living Carinarias observed during this study are as follows:



Text-figure 24. Radula teeth of *C. cristata* (L) of an individual from Sagami Bay.
a: half of a row, b: marginal, c: lateral, d: rhachdian.

i) *Carinaria cristata* from Sagami Bay: purplish.
ii) *Carinaria japonica* from St. 25′ of the *Sôyô-Maru*: Orange with faintly brownish particles on the posterior part of the gizzard.
iii) *Carinaria galea* from St. 43a of the *Sôyô-Maru*: Deep purplish red.

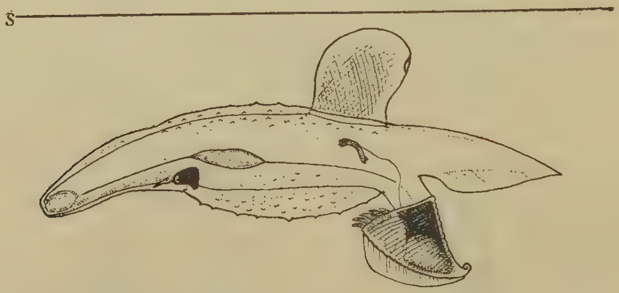
Yellowish coloration is caused by crustacean, while purplish coloration is probably caused by scyphomedusae, *Janthina* or amphipods, though this is not ascertained definitely.

3. *Swimming behavior*:

Living *C. galea* and *C. japonica* were observed by the present author on board the R. V. *Sôyô-Maru* in August 1958. Carinarias swam just like *Pterotrachea* (OKUTANI, 1957 c, pp. 17–19), but they kept themselves nearly always horizodtally while *Pterotrachea* usually keeps the body rather inclined when it is resting. The animal keeps the ventral side upwards and moves the fin as in file-fishes or puffers. In swimming the trunk winds like S, but the parts of the body seem hardly to contribute to locomation (Text-fig. 25).

4. *Possible predators of Carinaria*:

KING and IKEHARA (1959) reported that some heteropods were occasionally found in the stomach contents of tunas. However, It is not likely that tunas took those heteropods selectively. Although records of Carinarias being eaten by any predators are rare, it is met with very frequently that visceral nucleus of the animal is bitten off probably by some fishes. A kind of turtle may be regarded as one of the predators of them, because some Pterotracheas have been found from the stomach of the turtle (KURATA, unpublished).



Thxt-figure 25. *C. galea* in natural posture observed at St. 43a of the *Sôyô-Maru* on Sept. 12, 1958.
s: water surface.

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EXPLANATION OF PLATES XII–XIII

PLATE XII

Figure 1. *Carinaria cristata* (L.); a 240 mm long male from Kasajima, Sagami Bay, collected by NAKAMIGAWA, coll. 3907.

2–3. *Carinaria cristata* (L.); Shell of an individual from Tosa Bay, sH=22.6 mm (leg. TERAMACHI).

4. *Carinaria cristata* (L.); Darkly colored 340 mm long injured female from Niijima Isl. (Mr. Y. KURATA photo).

PLATE XIII

Figure 1. *C. cristata* (L), the same specimen with that shown in Pl. XII fig. 1.
a : anus, c : ctenidia, d : vas deferens, g : male gonad, k : kidney, l : liver, t : atrium of the heart v : ventricle of the heart.

2. *C. japonica* OKUTANI, type specimen, 62 mm. long female.

3. *C. lamarcki* PÉRON et LESUEUR; a 25 mm long female from the station 30°38.9′ N, 131°23.8′ E. (Mr. NAKAI orig.)

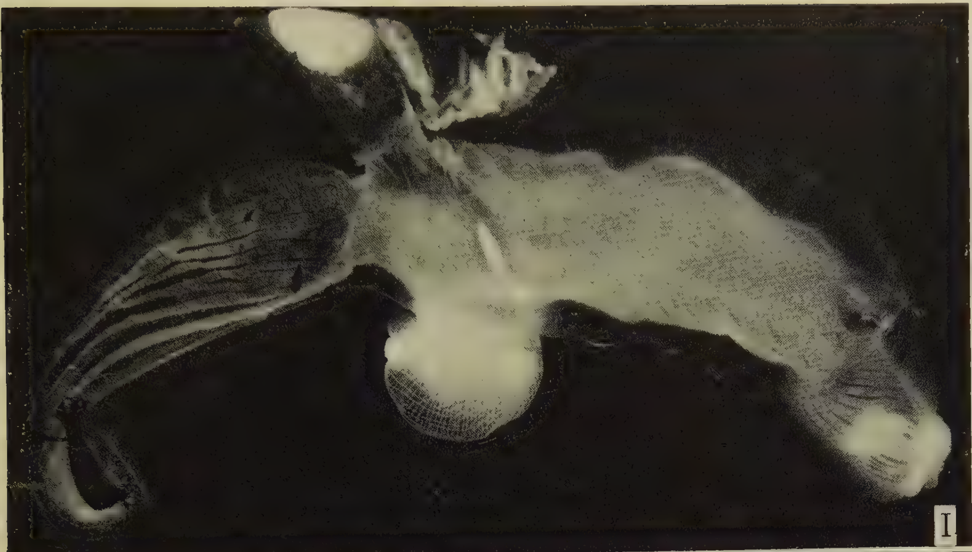
4. *C. galea* BENSON; a 21 mm. long female from the station 30°49.3′ N, 140°48.3′ E.

5. *C. galea* BENSON; shell of a male from the station 35°25′ N, 142°29′ E, sH=11.2 mm.

6a–b. *C. lamarcki* PÉRON et LESUEUR; shell of an individual from the station 32°46.3′ N, 133°08.8′ E, sH=3 mm.

7. *C. japonica* OKUTANI, shell of an individual from the station 43° N, 162° E, sH=5 mm.

8. *C. lamarcki challengeri* BONNEVIE; a 15 mm long female from the station 34°18′ N, 140°56′ E.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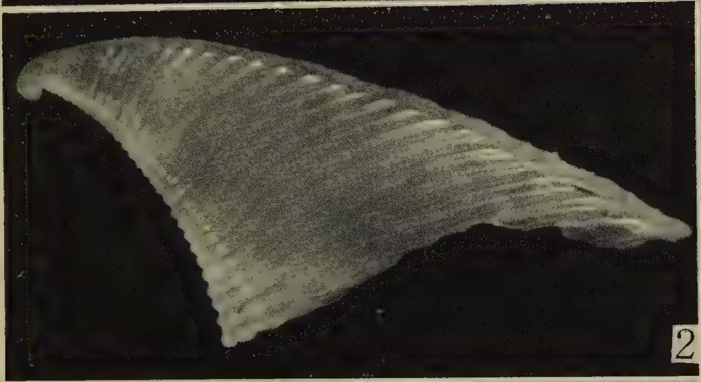
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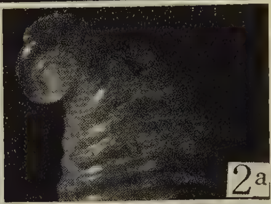
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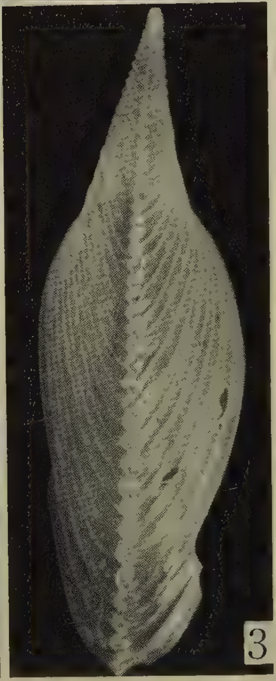
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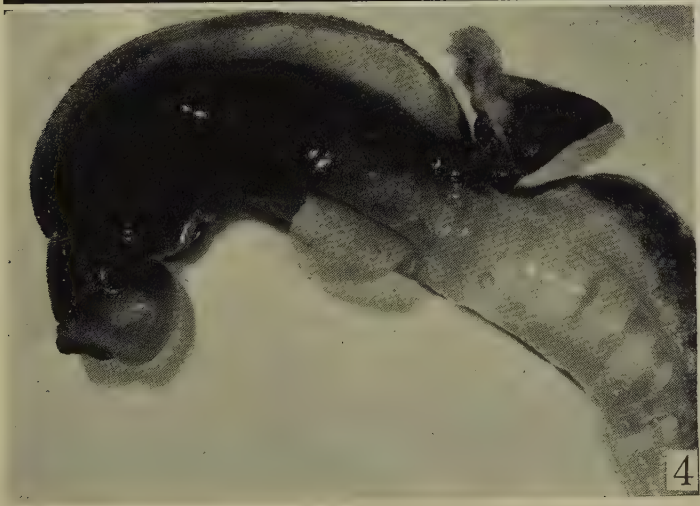
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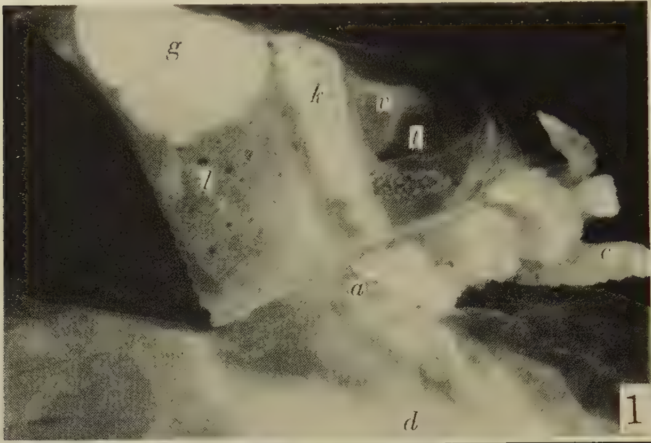
T. OKUTANI: NOTES ON THE GENUS *CARIÑARIA* (HETEROPODA).



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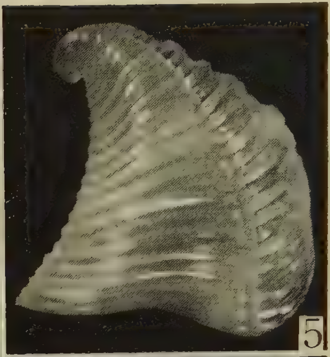

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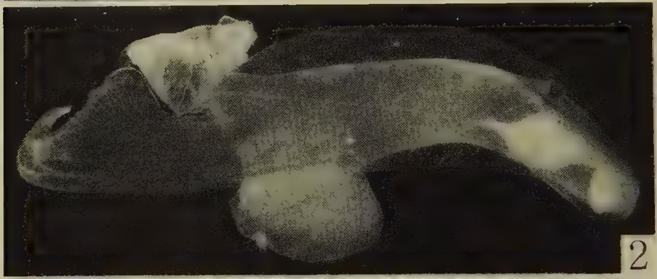

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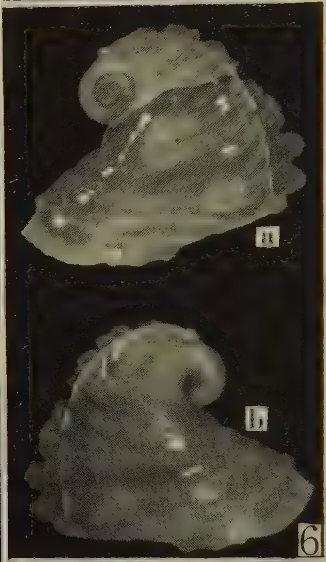

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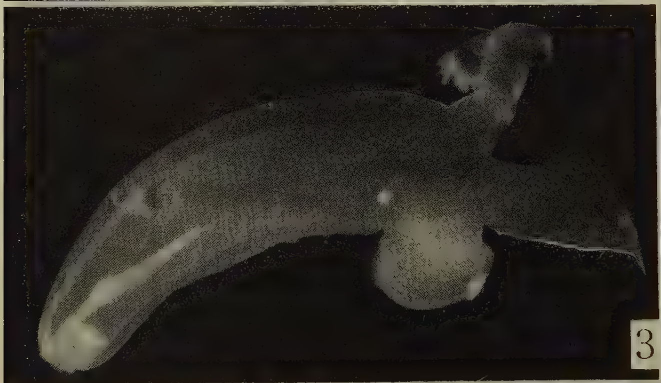

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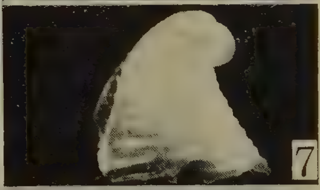

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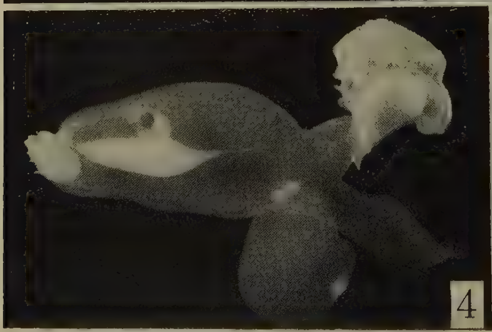

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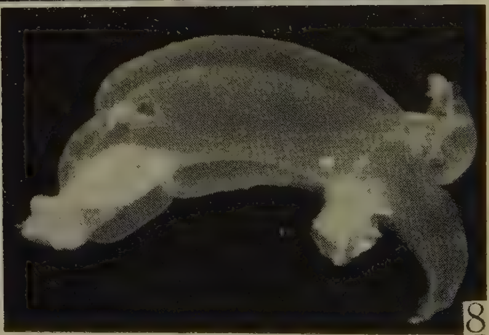

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T. OKUTANI: NOTES ON THE GENUS *CARINARIA* (HETEROPODA).

NOTES ON VELIGERS OF JAPANESE OPISTHOBRANCHS (4)[1,2]

Iwao HAMATANI
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With 8 Text-figures

Veligers of ten species of the Japanese Opisthobranchs were already described by the present author in three previous papers. Here, in this fourth paper, are added the following three species: *Doriopsis viridis* Pease and *D. aurantiaca* Eliot of Dorididae, and *Eubranchus misakiensis* Baba of Eolidacea. The first one was collected near the Seto Marine Biological Laboratory, while the second and the third were collected from Osaka Bay.

Doriopsis viridis Pease

(Figs. 1–3)

Several animals of this species (Fig. 1, A) (see Baba and Hamatani, 1961. pp. 63–65) and three egg-masses (Fig. 1, B) were collected from the under surface of a stone in a tide-pool on Hatake-sima in Tanabe Bay near the Seto Marine Biological Laboratory on July 23, 1960. One of these animals laid an egg-mass on the bottom of a glass-vessel on the next day of collecting. This egg-mass was quite the same as those found in the natural environment. It is coiled sinistrally 4¼ times, measures 12×25 mm in outline of the coil and is coloured faintly yellow. The ribbon is 1.5 mm wide and 95 mm in whole length; its free border is never longer than the attachment border so that the ribbon surface is never waved. Egg-capsules of the newly laid egg-mass (Fig. 2) are nearly oval in shape and 80 to 110 μ in long diameter. Ova are round and about 67 μ in diameter.

Early development: The observations were made on the above-mentioned egg-mass laid in a glass-vessel on July 24, 1960 when the room temperature was 31°C. The slight movement of embryo within the capsule began on the third day, the embryo passed into young veligers on the fourth day and attained the completed stage of veliger on the fifth day; at this time the egg-mass was tinted

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1) Contributions from the Seto Marine Biological Laboratory, No. 372.
2) A part of the studies supported by the financial aid granted from the Ministry of Education.

Publl. Seto Mar. Biol. Lab., IX (2), 1961. (Article 17)

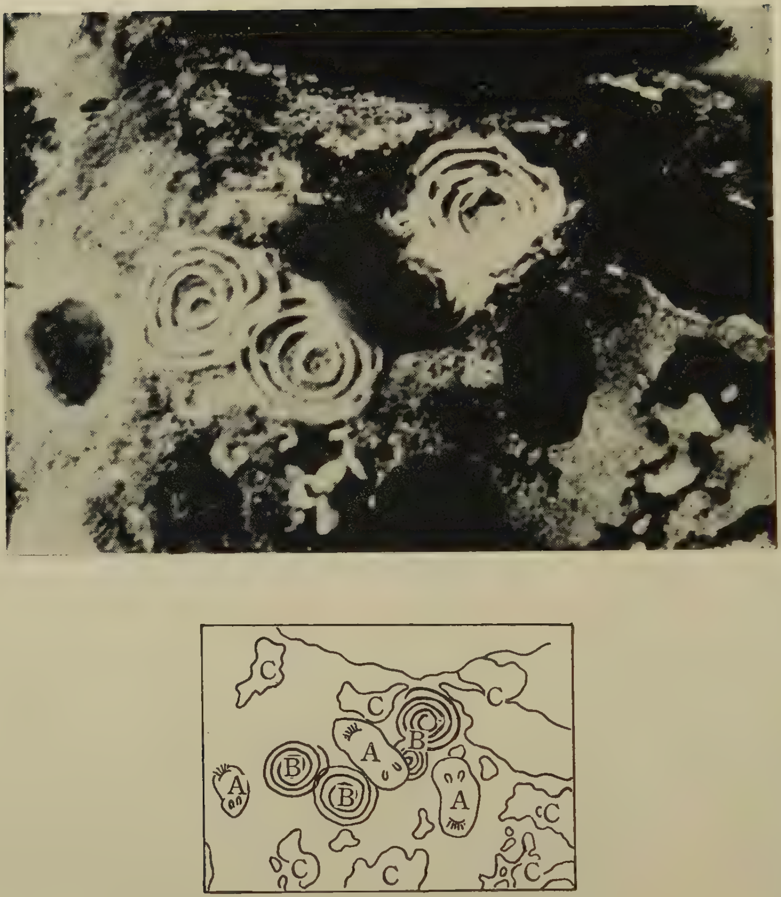

Fig. 1. *Doriopsis viridis* PEASE.
A. Slugs.
B. Egg-masses.
C. Keratose sponges.

Three faintly yellowish egg-masses are laid by indigo blue slugs which prey upon a keratose sponge which is extremely thin, fragile and coloured indigo blue just like the slugs1).

---

1) This picture was taken by Dr. I. YAMAZI of the Seto Marine Biological Laboratory on Hatake-sima in summer, 1961 and generously offered to the author. Here, the author wants to express hearty thanks for his kindness.

faintly purplish. The first hatching out was observed on the next day, thus it took about six days from the spawning to the hatching out of the first veliger at the room temperature from 27° to 34°C.

Veligers: The newly hatched veliger (Fig. 3, A) is transparent and rather small; its long diameter is 100 to 125 μ and short diameter is 75 to 80 μ on an average. The shell (Fig. 3, B and C) is sinistral, elongate ovoid in shape and $77 \times 100\ \mu$ on an average. It is faintly tinged purplish and has a sculpture consisting of a number of very small dots over the whole surface; particularly many minute granule-like ornaments are distributed on the axial half of the shell, especially densely near the aperture. The aperture is very large, occupying more than a half of the frontal projection of the shell. The operculum is circular in shape. The velum and subvelum are formed as usual, both contain several small refracting granules. The statocysts are well marked, although the eyes are absent. The foot is rather thick, covered with numerous short cilia all over the surface, and usually it does not protrude beyond the operculum edge; any special cells are not enclosed within it. The stomach has a thick wall enclosing some refracting granules. There are two liver lobes, the left one of which is larger than the right as usual, slightly purplish brown in colour, containing many refracting granules in its surface wall and shows a slight retractile movement. While, the right is slightly brownish in colour. There is only one large spherical body (1. sph.) on the right side of the veliger just behind the intestine, which is enclosed in a capsule-like sack. This body reminds one of three large spherical bodies of *Halgerda rubicunda* BABA (cf. HAMATANI, 1960), but the former differs distinctly from the latter in number and in that it is enclosed within the sack. Besides, there is a small spherical body (s. sph.) just behind the anus, which contains several minute granules; this body seems to correspond to that found in *H. rubicunda*. The nature of these bodies are quite unknown in this species,

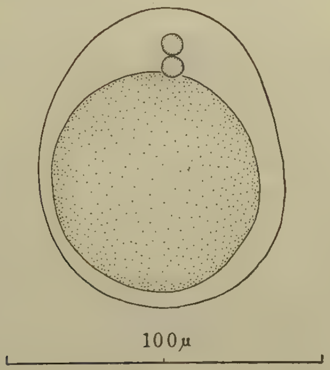

Fig. 2. *Doriopsis viridis* PEASE.
Ovum in the capsule.

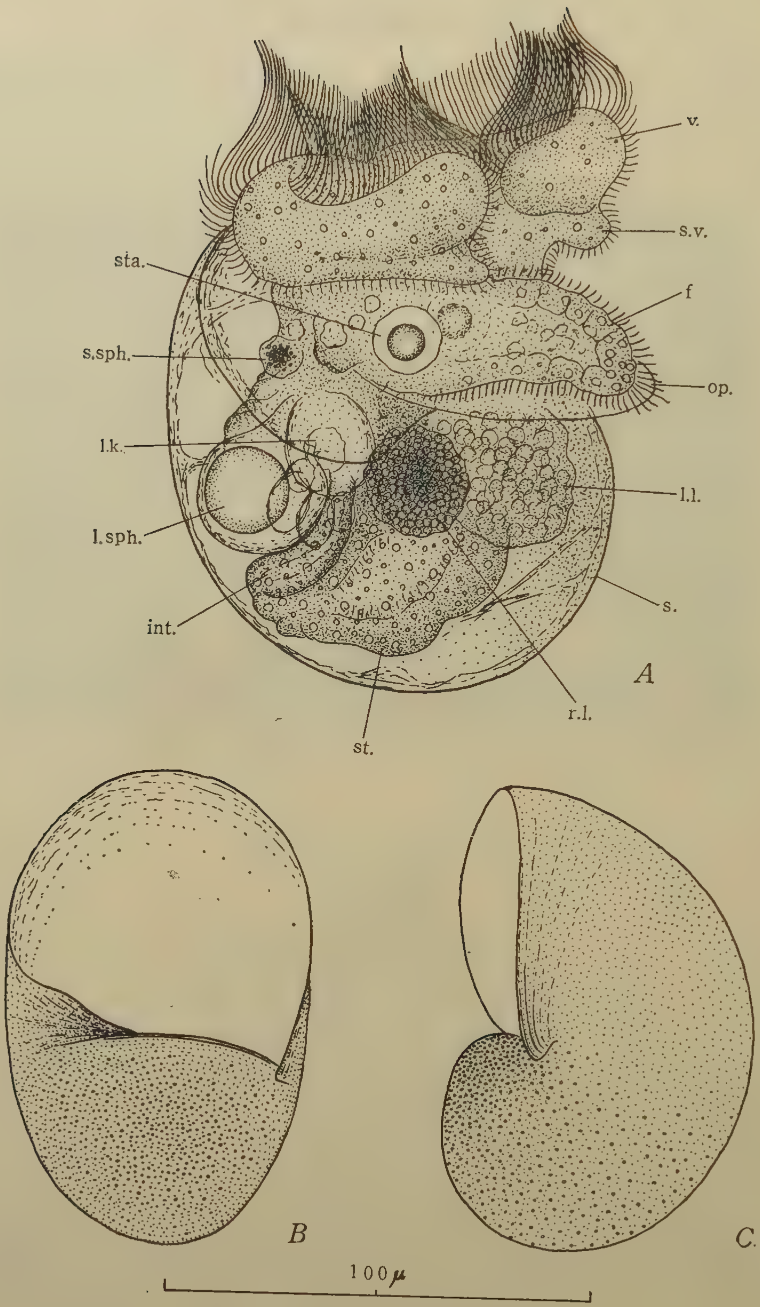

Fig. 3. *Doriopsis viridis* PEASE.

A. Newly hatched veliger, from the right side.
B. Larval shell, from the ventral side.
C. The same, from the apex.

Abbreviations: f.··· foot, int.··· intestine, l. sph.··· large spherical body, l. k.··· larval kidney, l. l.··· left liver, oes.··· oesophagus, op.··· operculum, r. l.··· right liver, r.m.··· retractor muscle, s.··· shell, s. sph.··· small spherical body, st.··· stomach, sta.··· statocyst, s. v.··· subvelum, un. o.··· unknown organ, v.··· velum.

either. The small spherical body behind the anus might be a rudimentary eye, although this is quite uncertain.

Doriopsis aurantiaca (ELIOT)

(Figs. 4–5)

The animals of this species are not rare on the shores of Osaka Bay. Only one examined egg-mass (Fig. 4), together with two animals of 25 mm long, was collected from the under surface of a stone at the shore of Ôkawa on the southeastern coast of the bay on August 27, 1961. This egg-mass (see also BABA and HAMATANI, 1961) is 15×20 mm in extent and its ribbon is 4 to 5 mm in width. It is coiled sinistrally 3 times and coloured yellow. Although the free border of the ribbon is somewhat wavy in the mass shown in Fig. 4, this is rather an exceptional case; generally it is scarcely waved. Usually one, rarely two, embryo is enclosed in a egg-capsule. Both the egg-capsule and the embryo are roundish in shape, the former is 140 μ and the latter is 100 μ in diameter.

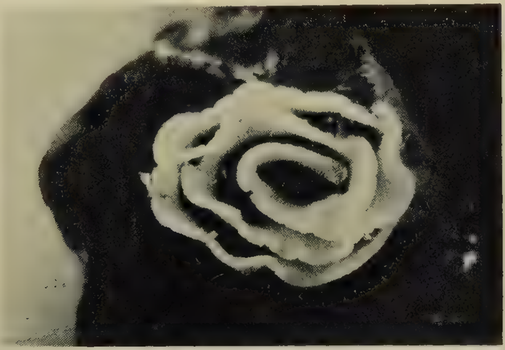

Fig. 4. *Doriopsis aurantiaca* (ELIOT). Egg-mass (Original photo taken at Ôkawa on August 27, 1961)

Early development: The egg-mass was brought in the laboratory and the further observations were made under the room temperature from 25° to 32°C. The embryo passed into the earliest stage of veliger on the day of collecting, and hatching out of larva from the egg-capsule took place on the fifth day.

Veligers: The newly hatched veliger of this species is just the same as that of the preceding species *Doriopsis viridis*. A large spherical body enclosed in a capsule-like sack is seen very distinctly just behind the intestine in this species, too. This species, however, differs clearly from the preceding species *D. viridis* in the following features of the veliger. The whole body of the veliger is larger than that of *D. viridis*, attaining about 165 μ in long diameter. The shell of the newly hatched veliger (Fig. 5) is transparent, although it is coloured very faintly purplish brown as a whole and with a deep dark brownish colouration along the axis of the shell. No sculptures are seen, except for this darkly coloured portion of the shell which is furnished with very minute dots. The shell is sinistral, nearly roundish in outline and about 140 × 160 μ in diameters in an examined specimen. The aperture is very large, occupying more than a half of the frontal projection of the shell and longer (antero-posterior) than wide; in *D. viridis* the aperture is evidently wide than longer (cf. Fig. 3, A). The operculum is circular in shape, about 100 μ in diameter, and with a spiral line.

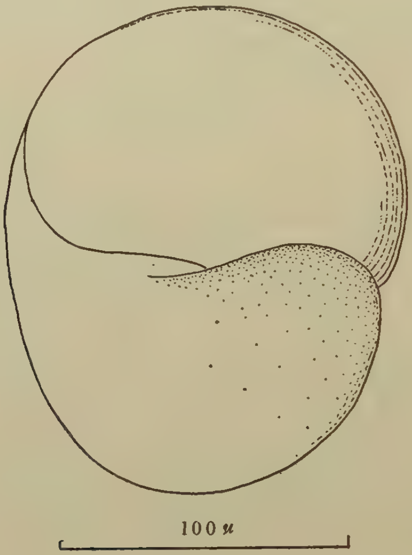

Fig. 5. *Doriopsis aurantiaca* (ELIOT).
Larval shell, from the ventral side.

Eubranchus misakiensis BABA

(Figs. 6–8)

This species was established by Dr. BABA in 1960. Many slugs of this species were found from the under surface of stones on the shore of Tannowa on March 6, 1961. In nature, the egg-laying takes place very frequently at the same place. The egg-laying can be observed easily on the bottom or wall of glass-vessel in laboratory. The egg-masses (Fig. 6, A) are in a form of slightly curved ribbon and 2 to 3 mm in breadth and 7 to 9 mm in length. It is milky white in colour and fastened to the substratum by its concave border. The egg-capsule of the newly laid egg-mass (Fig. 6, B) is oval in shape and about 115 to 160 μ in long diameter. Ovum is round and with about 90 μ diameter.

Early development: An animal laid an egg-mass in the glass-vessel on March 7, 1961, when it was 12°C in the room temperature. On the sixth day of the development the embryos passed into the earliest stage of veliger, at this time active rotatory motion of embryos in the capsule was observed. On the thirteenth day, the first hatching out of the veligers from the egg-mass was observed. The room temperature fluctuated from 6° to 21°C during the observations.

Veligers: The newly hatched veliger (Fig. 7) is wholly transparent and quite colourless. The shell (Fig. 8, A) is sinistral, ovoid in shape and 148×274 μ in size in a measured specimen. It is clear, colourless and devoid of any sculptures. The swollen portion of the thickening along the inner part of the axis is not so marked, but with one or two slight constrictions at just above the lower end of the thickening. The operculum (Fig. 8, B) is semicircular, about 80×100 μ in diameters in an examined specimen, and devoid of any sculpture line. The velum and subvelum are present as usual, both velar organs are rather small and devoid of any refracting granules. The foot does not protrude out beyond the operculum edge and it bears two long sensory cilia on each side. The stomach is usually slightly inclined to the right side from the transverse axis of the body. Eyes

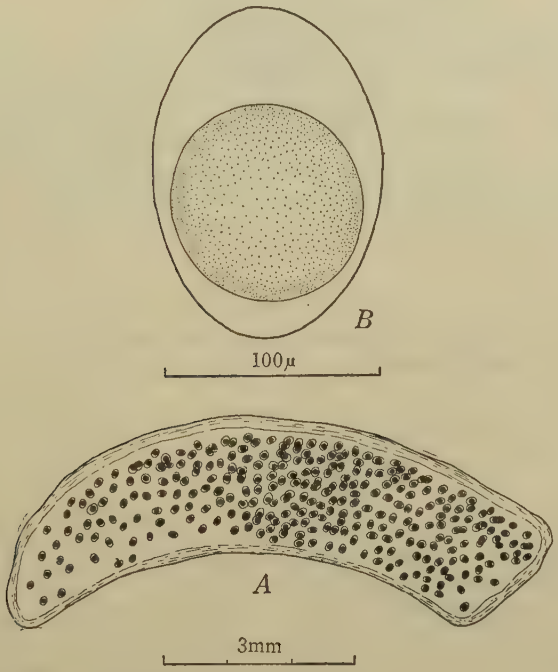

Fig. 6. *Eubranchus misakiensis* BABA.
A. Egg-mass.
B. Ovum in the capsule.

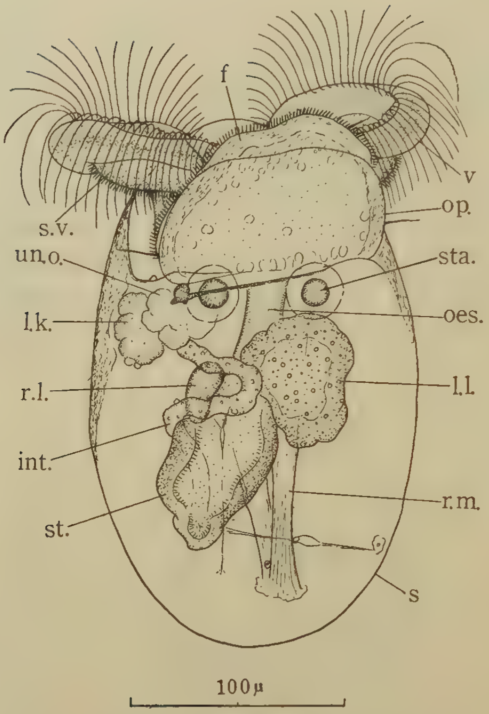
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Fig. 7. *Eubranchus misakiensis* BABA.
Newly hatched veliger, from the ventral side.

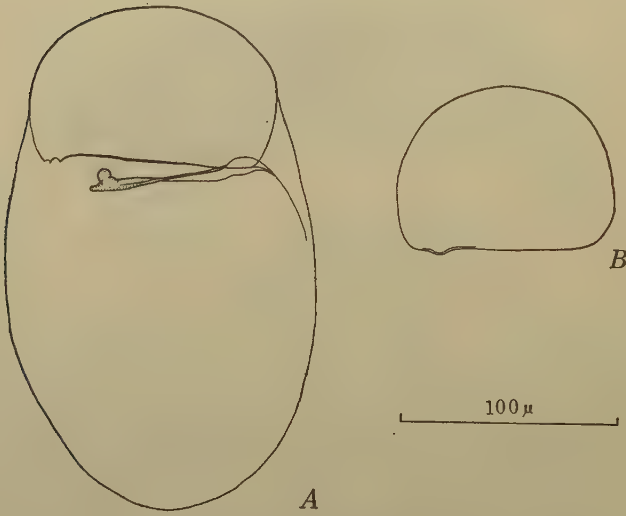

Fig. 8. *Eubranchus misakiensis* BABA.
A. Larval shell, from the ventral side.
B. Operculum.

are absent. There are two liver lobes as usual; and these are colourless. The larger left lobe is rounded and contains some refracting granules, while the smaller right one is elongated and devoid of any granules. The slender intestine is S-shaped and provided with small warty cells on the surface.

A roundish and unpigmented organ, presumably the larval kidney, is situated at just near the anus on the right side of the body. In addition, an unknown organ (un. o.) is seen at the ventral side of the anus; it is colourless and devoid of any granules. There is one small spherical body just behind each statocyst which contains several yellowish brown granules within it. It is not impossible that these spherical bodies are nothing but a pair of rudimentary eyes.

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PRELIMINARY ACCOUNT OF A NEW SPECIES OF *OKENIA* FROM OSAKA BAY, JAPAN (NUDIBRANCHIA-GONIODORIDIDAE)

Iwao HAMATANI

Sennan Senior High School, Tarui, Osaka Pref.

With 1 Text-figure

Six species of the genus *Okenia* (subg. *Okenia* s. s.) have been reported from our seas by Baba (1937–1960). While collecting on the rocky shore of Tannowa, Osaka Bay, on July 30 and August 12 of this year, I found specimens of a pretty nudibranch, 15 in total, which appeared to belong to the genus and subgenus mentioned above, probably forming a new species distinct from the previously recorded ones[1]. Their eggs were also formed in the native habitat of the parent animals. My thanks are due to Dr. Kikutaro Baba of the Osaka Gakugei University who has encouraged me to study these specimens, and generously let me use his collection of reprints for identification.

Okenia (*Okenia*) *babai* Hamatani n. sp.

Kohana-ibara-umiushi (n. n.)

(Fig. 1, A–D)

The living animals are limaciform, 3 to 5 mm in length, and 1 to 2 mm in breadth. The mantle-margin is membraneous, marked off from the sides, and provided with a series of 9 to 11 papillae on each side. Most of them are simple, claviform and pointed. The first papilla on each side is bifid. The last one on each side is also bifid, the main stem of the divisions being rather large and swollen towards the end. On the back there are short pointed papillae about 10 to 14 in number; of these, 3 to 4 are apt to be arranged along the median line from the interspace of two rhinophores to the very back of the gills. The general integument and the various papillae are finely spiculated. The sides of the body are smooth. The foot is narrower than the body, and rounded at the antero-lateral corners; it ends in a short pointed tail behind. The rhinophores

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[1] For the synopsis of the species of the genus *Okenia* from the world, see Marcus, 1957, pp. 436–438.

Publ. Seto Mar. Biol. Lab., IX (2), 1961. (Article 18)

are large, cylindrical, and perfoliated with 4 to 6 pinnae on the upper half. They are non-retractile. The branchiae consist of 7, simply pinnate, non-retractile plumes which are arranged in a semicircle round the anus. The oral tentacles are broad and lobiform. The genital opening is found usually between the fourth and fifth pallial papillae on the right side.

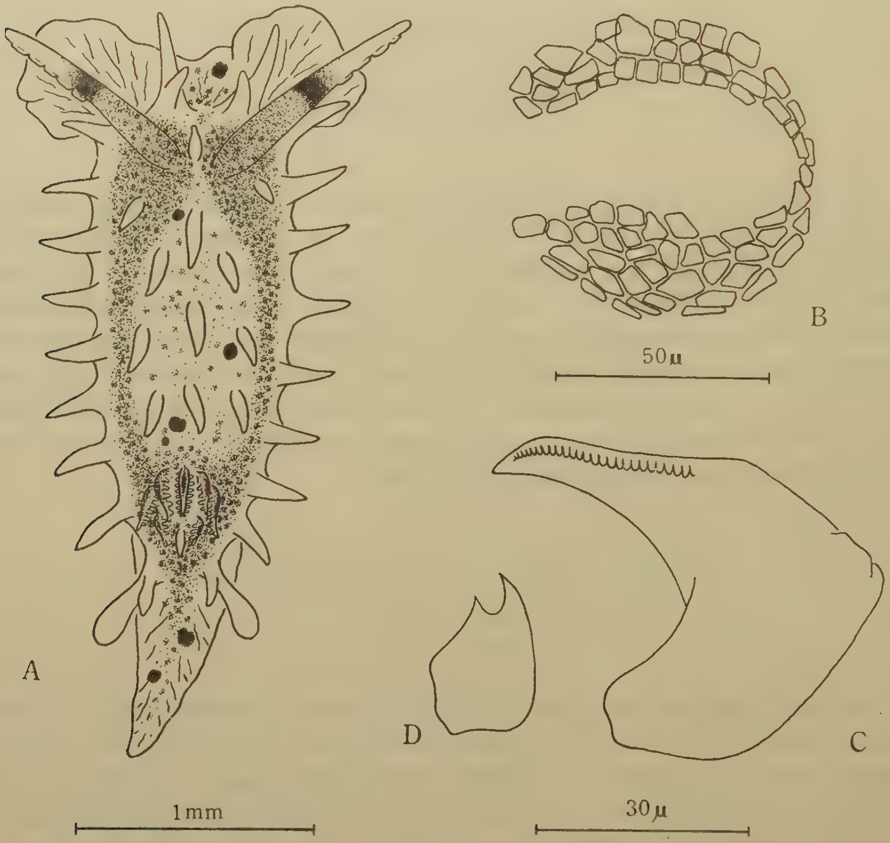

Fig. 1. *Okenia* (*Okenia*) *babai*.

A. Living animal (Tannowa, Osaka Bay; July 30, 1961).
B. Ring-shaped labial armature.
C. Inner lateral tooth of radula.
D. Outer lateral tooth of radula.

The ground-colour of the body is slightly yellowish white. Along the mantle-margin on each side of the back there is a greenish band, varying in intensity from dark green to black in different individuals. The two bands thus formed widen in front to cover the base of the rhinophores; posteriorly they unite round the gills and run down on the tail. Patches of green and orange-red may be distributed irregularly over the back, sides, tail, and raches of the gills. The rhinophores are greenish below, colourless above, and provided with an orange-red band in the middle of their length. The various papillae are colourless save the last pallial papillae which may sometimes be tinged with yellow.

The labial armature is an incomplete ring formed of tiny scales without hooks. The radula formulae are 26–34 × 1.1.0.1.1. The inner lateral tooth is large, hamate, and armed with a row of denticles on the inner edge of the cusp. The outer lateral tooth is smaller, scale-like, and bifid at the tip.

For its papillated aspect of the back this species reminds me of *Okenia* (*Okenia*) *echinata* BABA, 1949 and *O.* (*O.*) *opuntia* BABA, 1960, but it differs distinctly from them in the colouration of the body. Moreover, some further differences may also be seen in the number of the dorsal papillae, and in the configuration of the labial armature or of the outer lateral tooth. The species is dedicated to Dr. BABA.

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THREE NEW SPECIES OF THE GENUS *CATRIONA* FROM JAPAN (NUDIBRANCHIA-EOLIDACEA)[1]

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With Plates XIV–XV and 1 Text-figure

The acleioproctic family Cuthonidae consists of the genera: *Cuthona*, *Precuthona*, *Cuthonella*, *Phestilla*, *Catriona* (=*Cratena* in older use), *Cratenopsis*, *Indocratena*, *Xenocratena*, *Njurja*, ?*Diaphoreolis*, ?*Noumeaella*, ?*Globiferina*, ?*Ennoia*, ?*Myja*, ?*Dunga*, ?*Zatteria* and ?*Guy-valvoria*.

Catriona is a large genus (see the synopsis of the species by MARCUS, 1958, pp. 49–52). It is especially distinct from the allied genus *Cuthona* in having a chitinous armature of the penis (penis stylet). The male and female orifices are united. The median cusp of the radula teeth is not so prominent like in *Cuthona*, and sometimes it is retracted (see the distinction of *Catriona* from *Cuthona* given by ODHNER, 1939, p. 53; E. & E. MARCUS, 1959, pp. 917-918; see also MACNAE, 1954, pp. 3–4). The species of *Catriona* previously recorded from our seas are enumerated below[2]:

1. *Catriona ornata* (BABA, 1937)=*Cuthona ornata* BABA, 1937 Fujiera-minoumiushi
   Loc.: Sagami Bay; Sugashima near Toba; Osaka Bay; Inland Sea of Seto; Sado I.; Toyama Bay; Togi Kazanashi, W. coast of Noto Peninsula; Tsuruga Bay.
   Penis armed with stylet.
2. *Catriona venusta* (BABA, 1949) = *Cratena venusta* BABA, 1949 Hanazono-minoumiushi
   Loc.: Sagami Bay.
   Penis not determined.
3. *Catriona anulata* (BABA, 1949) = *Cratena anulata* BABA, 1949 Tsunowa-minoumiushi
   Loc.: Sagami Bay.

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1) Contributions from the Seto Marine Biological Laboratory, No. 373.

2) *Amphorina*? sp. ELIOT, 1913, is left undetermined. *Cratena bicolor* (BABA, 1933)=*Cuthona bicolor* BABA, 1933 (non *Cuthona*? *bicolor* BERGH, 1904) is excluded from *Catriona* (see MARCUS, 1958, p. 49); it will be discussed later.

Publ. Seto Mar. Biol. Lab., IX (2), 1961. (Article 19)

Penis not determined.

4. *Catriona pinnifera* (BABA, 1949) = *Cratena pinnifera* BABA, 1949 Tsunobane-minoumiushi

   Loc.: Sagami Bay; Kii; Osaka Bay; Toyama Bay; Tsuruga Bay.

   Penis armed with stylet.

5. *Catriona puellula* (BABA, 1955) = *Cratena puellula* BABA, 1955 Kirihime-minoumiushi

   Loc.: Sagmi Bay; Toyama Bay.

   Penis not determined.

6. *Catriona nigricolora* (BABA, 1955) = *Cratena nigricolora* BABA, 1955 Kuro-minoumiushi

   Loc.: Sagami Bay.

   Penis not determined.

Catriona pupillae BABA, n. sp.

Komayu-minoumiushi (n. n.)

(Pl. XIV, Figs. 1, a, b–5; Text-fig. 1, A)

This species is somewhat allied to *C. susa* E. & E. MARCUS, 1959, from the Red Sea, in the arrangement of the gills. Animal always small, 3–5 mm in total length. With cephalic tentacles and rhinophores, the latter slightly longer and smooth. Branchial papillae short, of an inflated fusiform, arranged in 4–6 simple oblique rows on each side, about 3–4 in the largest rows, the foremost 2 rows belonging to the right liver (and the left partner). Genital orifice situated below the 1st row on the right side, the anus in front of the 3rd row on the same side, the nephroproct closely preanal. Foot-corners rounded. General body-colour translucent whitish, covered with opaque white dots on head and back. Cephalic tentacles and rhinophores nearly always marked with an orange-yellow band at about the middle of their length. Branchial papillae with an opaque white cap and a band of the same colour down the tip; liver diverticulum within the papillae, dark brown. A row of 17–20 denticles on the masticatory edge of the jaw-plates. Radula formula 30 × 0.1.0. The median cusp of the tooth is slightly longer than the lateral (4–5) denticles. In *C. susa*, it is said that each of the teeth has 3 median cusps longer than the lateral denticles. Genitalia as usual in the genus, the penis having an apical stylet.

Loc.: Tannowa, Osaka Bay, shallow water (Mar. 1951 and 1952, 4 sps., coll. by Mr. HAMATANI); Kada, Osaka Bay (Mar. 1957, 2 sps., coll. by Mr. HAMATANI).

Additional localities of this species are: Mukaishima, Inland Sea of Seto; Nou and Awashima, Niigata Pref.; Toyama Bay; Tsuruga Bay; not rare. The actual specimens in these stations have been obtained by Dr. INABA as well as by Mr. ABE and his co-workers.

Catriona signifera BABA, n. sp.

Monsyo-minoumiushi (n. n.)

(Pl. XIV, Figs. 6, a, b–9; Pl. XV, Figs. 1–2; Text-fig. 1, B)

Very distinctive in having an ovoid marking behind the rhinophores on the back. Total length of animal 5–8 mm. Rhinophores as long as the cephalic tentacles, smooth. Branchial papillae long fusiform, arranged in 8–9 simple oblique rows on back margins, about 3–4 in the largest rows, the foremost 3 rows belonging to the right liver (and the left partner). Genital orifice below the 2nd row on the right side, the anus in front of the 4th row on the same side, the nephroproct closely preanal. Foot-corners rounded. General body-colour translucent white, inclined to yellowish above, sprinkled with opaque white dots on head, back and tail. Upper half of cephalic tentacles and rhinophores opaque white. Branchial papillae opaque white towards the tip, their surface often streaked with longitudinal opaque white lines. Liver diverticulum within the papillae, dark green. The ovoid marking on the back is dark brown to black. Masticatory

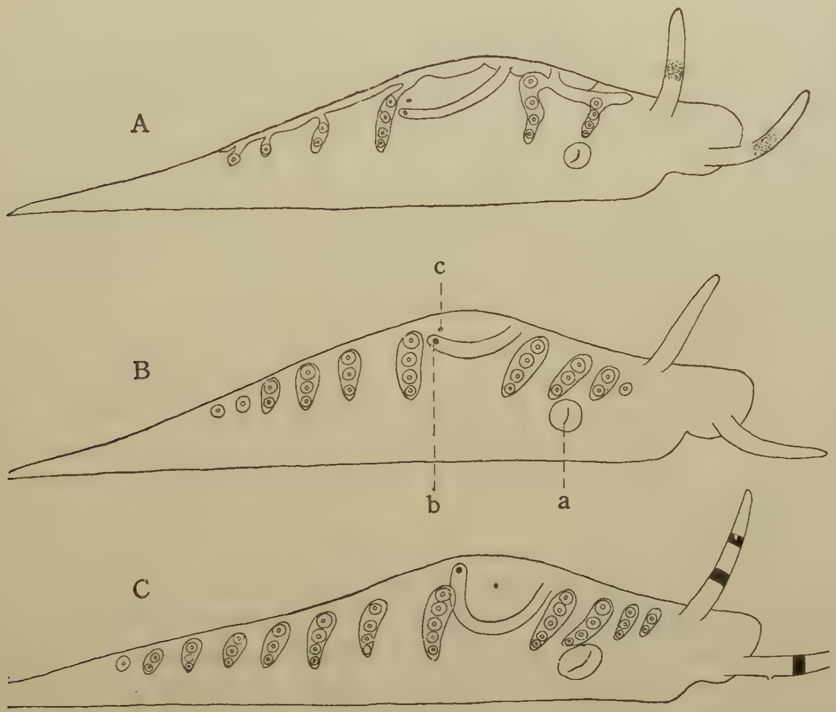

Fig. 1. Right side views of the three new species of *Catriona*.
A. *C. pupillae* (Mukaishima, Inland Sea of Seto); B. *C. signifera* (Tannowa, Osaka Bay); C. *C. purpureoanulata* (Mukaishima). a. genital orifice, b. anus, c. nephroproct.

edge of the jaw-plates with a row of about 14 denticles. Radula formula 14×0.1.0. Median cusp of the tooth as large as the lateral (5–6) denticles.

Loc.: Tannowa, Osaka Bay, on shore (Mar. 1951 and 1959, 12 sps., coll. by Mr. HAMATANI); Mukaishima, Inland Sea of Seto, on *Sargassum* weeds in shallow water (Mar. 1960, 27 sps., coll. by Dr. INABA).

Catriona purpureoanulata BABA, n. sp.

Yubiwa-minoumiushi (n. n.)

(Pl. XV, Figs. 3, a, b–8; Text–fig. 1, C)

Animal 6–10 mm in length. Cephalic tentacles and rhinophores smooth. Branchial papillae long fusiform, disposed in 11–13 simple oblique rows on each side, 4–5 in the largest rows, the foremost 3–4 rows belonging to the right liver (and the left partner). Genital orifice below the middle of the right liver rows, the anus just in front of the 1st right row of the posterior liver, the nephroproct moderately preanal. Foot-corners rounded. Coloration distinctive in having a purple band down the tip of each of the branchial papillae. Two bands of purple occur also on cephalic tentacles and rhinophores each. General ground-colour translucent whitish, part of head and back covered with clusters of opaque white (or yellowish) dots. The two structures of the head also opaque white towards the tip. The cap of the branchial papillae opaque white, each papilla having a dark brown liver diverticulum. Foot-margin sometimes with a fine line of purple. A row of 15–17 denticles on the masticatory edge of the jaw-plates. Radula formula 22×0.1.0. The median cusp of the tooth is as large as the lateral (usually 5) denticles.

Loc.: Seto, Kii, shallow water (June 1951, 1 sp.); Tannowa, Osaka Bay, shallow water (July 1957, 1 sp., coll. by Mr. HAMATANI).

Additional localities of this species are: Hayama, Sagami Bay; Mukaishima, Inland Sea of Seto; Awashima, Niigata Pref.; Mera, Fukui Pref.; Tsuruga Bay; not rare. The actual specimens in these stations have been collected by His Majesty's Biological Laboratory, Dr. INABA, Mr. ABE and his co-workers.

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Postscript

Cotasiella formicaria (BABA, 1959) = *Stiliger* (*Stiliger*) *formicarius* BABA, 1959. This revised identification has been suggested to me by Dr. C. J. Risso DOMINGUEZ in Argentine, marking the similarity of *formicarius* to *Costasiella* PRUVOT-FOL, 1951 (type: *C. virescens* from the Mediterranean) in the tentacular foot-corners and especially in the peculiar situation of the eyes lying close together. The genus *Costasiella* may be excluded from the Oxynoidae. References: BABA, K. 1959. The family Stiligeridae from Japan (Opisthobranchia-Sacoglossa). Publ. Seto Mar. Biol. Lab., vol. 7, no. 3, p. 329. PRUVOT-FOL, A. 1951. Étude des nudibranches de la Méditerranée. Arch. Zool. Exp. et Gén., tom. 88, fasc. 1, p. 73.

EXPLANATION OF PLATES XIV–XV

PLATE XIV

Fig. 1a. *Catriona pupillae* (Tannowa, Osaka Bay, Mar. 13, 1951, length 5 mm).

Fig. 1b. The same. A branchial papilla.

Fig. 2. The same. Jaw-edge (×580).

Fig. 3. The same. A radula tooth (×580).

Fig. 4. *Catriona pupillae* (Mukaishima, Inland Sea of Seto, Mar. 12, 1960, length 4 mm). Diagrammatic representation of the internal anatomy. a. pharynx, b. oesophagus, c. stomach, d. genital orifice, e. right liver, f. rectum, g. nephroproct, h. anus, i. testes, j. ovaries, k. posterior liver, i. left liver, m. special oral gland, n. salivary gland.

Fig. 5. The same. Diagrammatic representation of the genitalia. a. penis, b. penis sac, c. penis stylet, d. genital orifice, e. vas deferens (glandular part), f. spermatheca, g. oviduct, h. albumen gland, i. hermaphrodite duct, j. mucous gland, k. ampulla, l. penis gland.

Fig. 6a. *Catriona signifera* (Tannowa, Osaka Bay, Mar. 13, 1951, length 8 mm).

Fig. 6b. The same. Two branchial papillae.

Fig. 7. The same. Jaw-edge (×580).

Fig. 8. The same. A radula tooth (×580).

Fig. 9. *Catriona signifera* (Mukaishima, Inland Sea of Seto, Mar. 15, 1960, length 7 mm).

PLATE XV

Fig. 1. *Catriona signifera* (Tannowa, Osaka Bay, Mar. 13, 1951, length 8 mm). Diagrammatic representation of the internal anatomy. a. genital orifice, b. nephroproct, c. anus.

Fig. 2. The same. Diagrammatic representation of the genitalia. a. penis. b. penis stylet, c. spermatheca, d. albumen gland, e. ampulla, f. mucous gland, g. penis gland.

Fig. 3a. *Catriona purpureoanulata* (Seto, Kii, June 22, 1951, length 6 mm).

Fig. 3b. The same. A branchial papilla.

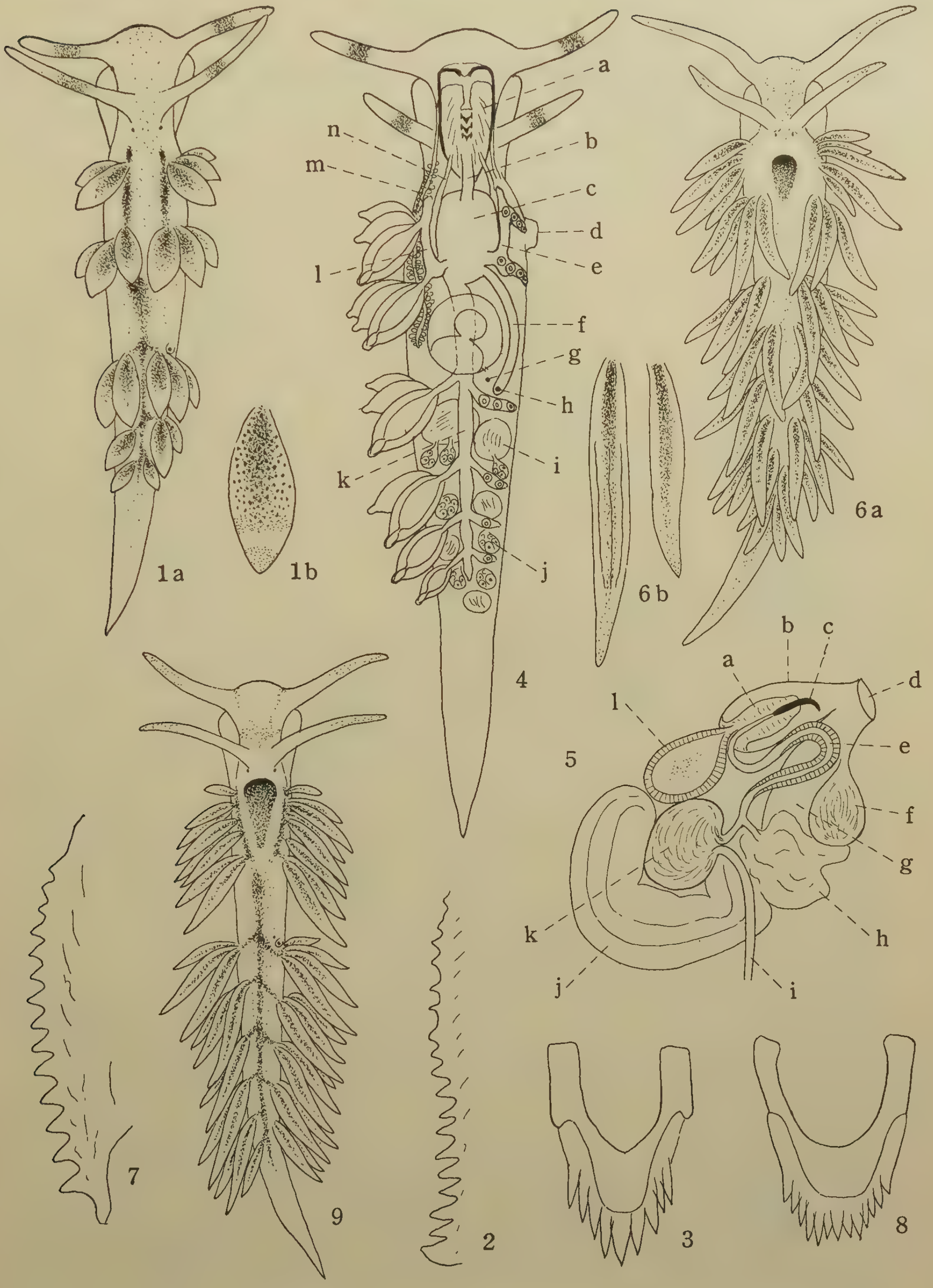
Fig. 4. The same. Jaw-edge (×580).

Fig. 5. The same. A radula tooth (×580).

Fig. 6. *Catriona purpureoanulata* (Mukaishima, Inland Sea of Seto (Apr. 2, 1961, length 2 mm). Diagrammatic representation of the internal anatomy. a. genital orifice, b. nephroproct, c. anus, d. kidney.

Fig. 7. The same. Part of the special oral gland (×60).

Fig. 8. The same. Diagrammatic representation of the immature genitalia. a. penis stylet, b. spermatheca, c. accessory female gland, d. ampulla, e. penis gland.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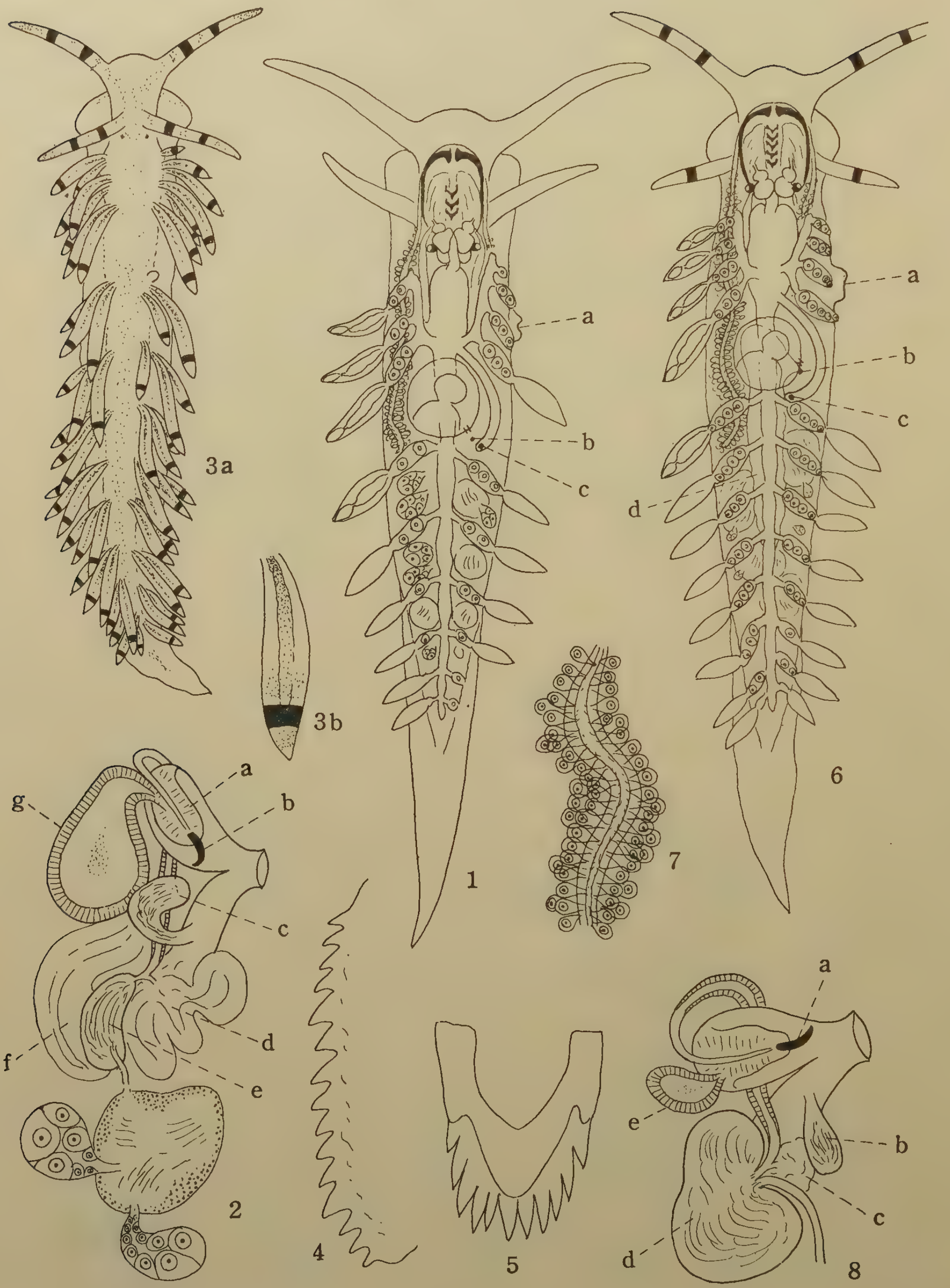
K. BABA: THREE NEW SPECIES OF THE GENUS *CATRIONA* FROM JAPAN.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K. BABA: THREE NEW SPECIES OF THE GENUS *CATRIONA* FROM JAPAN.

RHYTHMIC ACTIVITY OF THE SEASIDE BARNACLE *TETRACLITA SQUAMOSA JAPONICA* PILSBRY IN WINTER[1]

Syuiti MORI

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With 3 Text-figures

Introduction

I had already published on the rhythmic activity of the seaside barnacle, *Tetraclita squamosa japonica* Pilsbry, saying that the rhythmic protruding activity of the feet was controlled by change of light and of water caused by dashing waves, and food had scarcely no relation with normal induction of the said activity (Mori, 1958).

Since then, however, when I visited the natural habitat near the Seto Marine Biological Laboratory of Kyoto University in winter, I noticed that the feature of the activity was somewhat different from that of observed in summer. Namley, they often protruded their feet in the daytime, which had never been observed in summer.

Are there then really any differences between the mode of the rhythmic activity of summer and of winter? And if any, what are the causes that evoked these differences? In order to solve these questions I performed some natural observations and laboratory experiments, which are described in this paper.

Refferring the literatures, we can find the works performed by Southward (1955 and 1957). He investigated the relation between cirral acitivity and water temperature, but the standpoint was from purely physiological, and the adaptation problem found among various species distributing from north to south was widely treated. So that I could not find out any literatures concerning directly with such facts as mentioned in the present paper.

The author wishes to express his sincere thanks to Professor H. Utinomi and other members of the Seto Marine Biological Laboratory, who offered many facilities during the course of the work.

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1) Contributions from the Seto Marine Biological Laboratory, No. 374.

2) Present address: Otsu Hydrobiological Station, Kyoto University, Otsu, Japan.

Publl. Seto Mar. Biol. Lab., IX (2), 1961. (Article 20)

Observations at the natural habitat

Three plots were selected on the rocks near the Laboratory, the numbers of the barnacle inhabited there were 55, 50 and 28 respectively. The observation was performed from 13:30 of Jan. 12 to 10:00 of 15. The number of individuals that were protruding the feet was counted at adequate intervals. Water temperature, air temperature, relative humidity, depth of water where the animals inhabited and intensity of light, were measured simultaneously.

Results obtained at the plot No. 1 are illustrated as the representative in Fig. 1. It can be concluded from this figure and other observations that;

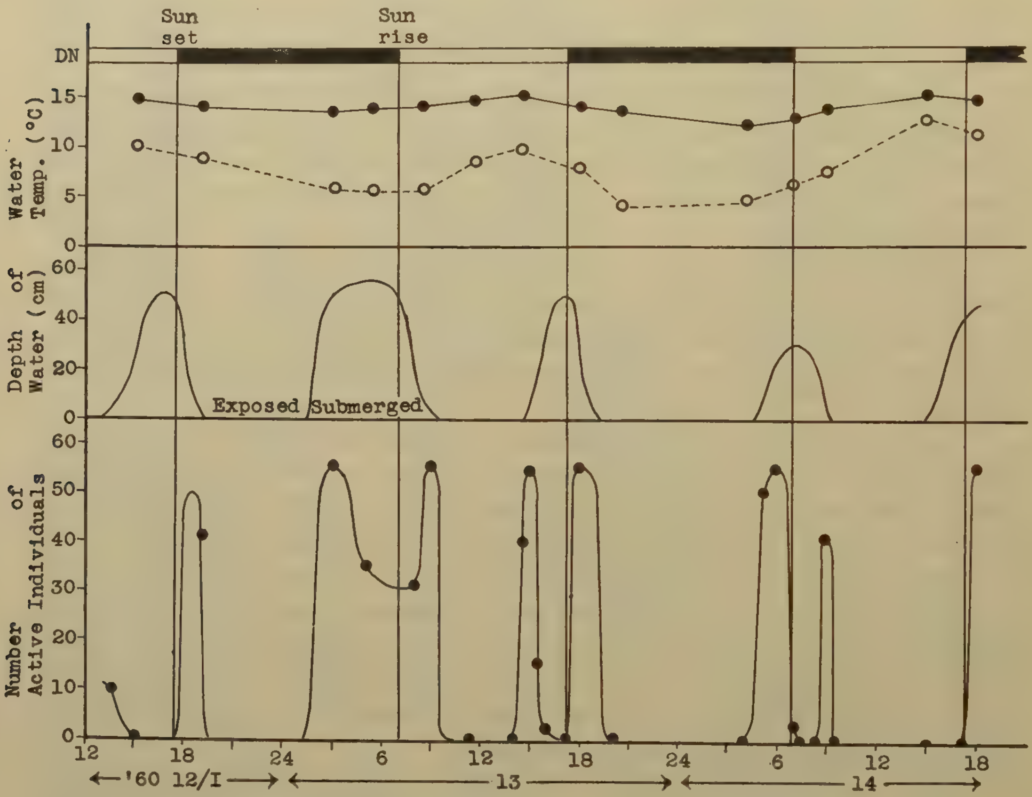

Fig. 1. Daily march of the activity of *Tetraclita squamosa*, with changes of the physical environments, at the plot No. 1.
DN: showing day (white span) and night (black span) change.
Upper figure: change of water temperature (—●—) and air temperature (---○---). Note that water temperature is much higher and the change is more stable.
Middle figure: change in depth of water and in period when the barnacles were submerged.
Lower figure: change of activity, indicated by the number of individuals which were protruding actively their feet.

a) At night: General feature of the activity is similar to that observed in summer. But there seems to occur a slight decrease in activity at the time of the highest flood.

b) In the daytime: When rising water comes and dashing waves wash the animals vigorously they protrude the cirri for a while (more or less 30 minutes) and then close the shells untill night comes when they begin the natural nocturnal activity. However, it must be noticed that in the evening of Jan. 14 they did not show any activity, even when they were washed by the dashing waves, until night came. Two reasons seem to be considered at this time as follows. First, the sea was very calm this evening and consequently the waves did not dash so strongly on the animals that the stimulating agency was insufficient. Secondly, the air temperature was so high that the difference between it and water temperature was not significant as to act as stimulating agency. This last point will be discussed in detail later on. Which of these two causes was importan is not clear at present, but perhaps both might have cooperated.

Then, when the tide is falling and the animals become to be washed by the waves now and then, they begin to protrude the feet; this activity continues also for about 30 minutes, and ceases when the animal body is entirely exposed above water.

c) As environmental conditions of winter which are different from those of summer, we must point out temperature condition. Of coure, temperature is remarkably higher in summer than in winter. And also in summer in the daytime, the water temperature (27–30°C) is much lower than the air temperature near the surface of rock (27–36°C, the difference between the two is generally 5–6°C), whereas they are very similar in the nighttime (both about 26–27°C). On the contrary in winter, the water temperature is remarkably higher than the air temperature throughout a day, viz., the former remains between 13 and 15°C throughout a day, whereas the latter changes between 4 and 13°C (usually below 10°C).

As described above, the different manner of the activity observed between summer and winter seemed to have their cause in the difference of these temperature conditions. The following experiments were planed to make clear this point.

Analysis of behavior by laboratory experiments

Broken pieces of rock with the attached barnacles (with 80 to 150 individuals) were brought into the laboratory and placed in the glass aquaria under natural light condition. The water was flowed quietly and constantly, and under this condition they never protruded the feet. At adequate intervals they were suddenly subjected to the strong current, which was generated by the water running out from a rubber water-pipe. Some of them protruded the feet against the current.

The water temperature was changed as follows. The flowing water was always passed through a long glass tube, which was whirled in the water bath. The temperature of the water in the bath was controlled by the electric heater. so that the temperature of water flowing through the glass tube could be artificially controlled and consequently the environmental temperature of the barnacles could be regulated.

Figs. 2 and 3 show the results. Both the change of water temperature and the number of animals protruded their feet against the current shock are shown.

From these experiments it will be concluded as follows.

a) When the animals, having been subjected to low temperature, are subjected to sudden rise of temperature provided with strong corrent of water, they protrude their feet actively, irrespective of it is in the daytime or in the night-time. However, the degree of this activation seems to be a little higher at night.

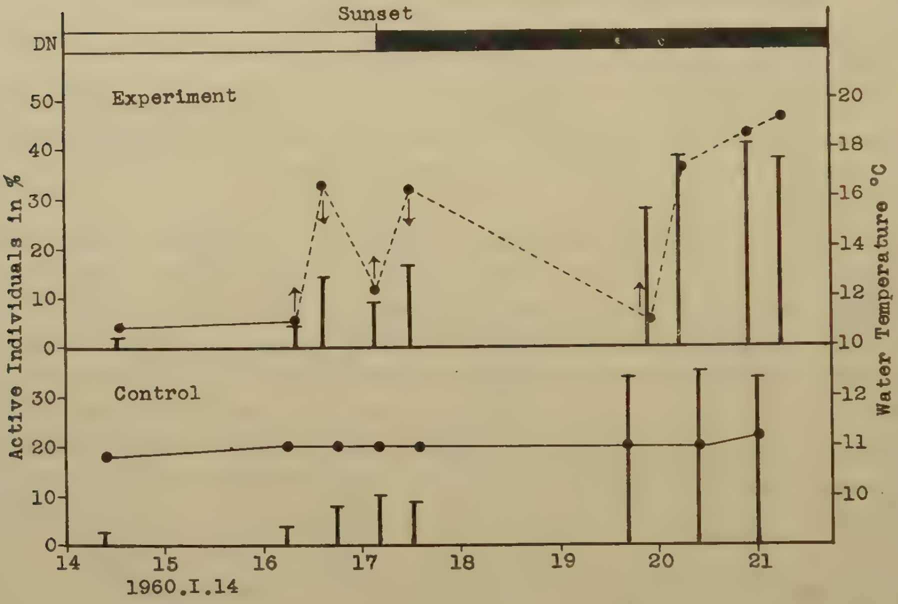

Fig. 2. Change in the protruding activity of the feet against the current shock with the change of water temperature.
Upper figure, experiment, using a piece of rock attached with 91 individuals.
Lower figure, control, using a piece of rock attached with 80 individuals.
—●— natural change and ---●--- experimental change of water temperature.
Vertical bars show active individuals in percent which protruded the feet when subjected to the strong current. ↑ indicates the time when water temperature began to rise and ↓ that when water temperature began to fall.
DN shows day and night proceeding.

b) Control animals which have never been experienced the sudden temperature change show the typical summer type of rhythmic activity, that is, the activity is much lower in the daytime than in the nighttime.

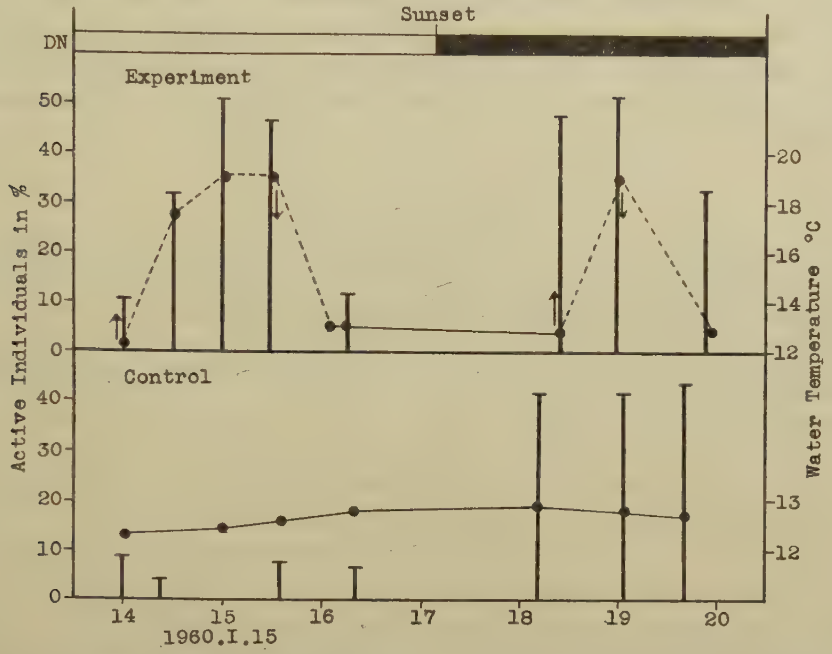

Fig. 3. Same kind of expeirment as Fig. 2. A piece of rock used as experiment was attached with 156 individuals and that used as control was with 147 individuals.

Conclusion

From above observations and experiments the author considers the causes of daytime activity of the seaside barnacle *Tetraclita squamosa japonica* Pilsbry in winter, as follows:

The general low temperature, provided with high water temperature relative to the low air temperature is noticeable in winter, and when the water surrounding the animals is going to rise or fall the environmental temperature may change suddenly, and this environmental temperature change together with the strong current caused by dashing waves stimulate the animals to protrude the feet. This behavior usually continues about 30 minutes.

On some hot days in summer the animals will experience the similar kind of temperature change (although the water temperature may be lower than the air temperature), but in this case the animals do not react to this environmental chang. So that, in other words, the low temperature seems to lower the inhibitory action of daylight in winter. Of course the stimulation by strong current is always necessary to protrude the feet. Really, on the day of very calm and warm day in winter, they never show this daytime activity, the reason of which may easily be supposed from above consideration. Of course at night, when there is no inhibitory action of light, they show the routine pedal activity so long as they are submerged; however, the degree of the activity seems to decrease slightly at the time of the highest flood, which has never been observed in summer.

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STUDIES ON THE HEAT RESISTANCE OF *TIGRIOPUS JAPONICUS*[1]

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With Plates XVI–XVII and 16 Text-figures

The copepod, *Tigriopus japonicus* Mori, is a microscopical marine organism which inhabits small pools on rocks exposed above the sea. Since its habitat is situated well above the high tide mark, this species is always subjected to rapid and drastic changes of environmental conditions. Such pools with limited quantities of water are very susceptible to the daily and annual fluctuations of solar radiation and air temperature. Water temperature may rise above 40° in summer and fall down toward 0°C in winter. Salinity is liable to be changed steeply by concentration due to evaporation and by dilution with rain water. Oxygen concentration may also vary considerably because of the smallness of water volume in comparison to the abundance of organisms.

Such being the habitat, *Trigriopus* is expected to possess a high degree of capacity to adapt itself in response to changes in the environment. Takeda (1954), studying the temperature acclimatization in this species, found that its heat tolerance was affected markedly by its thermal history. This noteworthy study was discontinued by his regrettable death. The present writer was much interested in the findings of Takeda and has undertaken the present investigation to trace his experiments and further to analyse the mechanism underlying the temperature acclimatization of this species.

The phenomenon of temperature acclimatization in poikilotherms has long attracted the attention of many biologists and it has become of recent years an increasingly fascinating object of inquiry in the field of animal physiology and ecology. There is an enormous mass of information available on this phenomenon (*e.g.*, Loeb and Wasteneys 1912, Brett 1944, 1946, Doudoroff 1942, 1946), which was summarized and reviewed by some authors, such as Precht (1958) and

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[1] Contributions from the Laboratory of Animal Physiology, Osaka City University, No. 64.
Contributions from the Adaptive Variation Research Group, No. 53.
Contributions from the Seto Marine Biological Laboratory, No. 375.

Publ. Seto Mar. Biol. Lab., IX (2), 1961. (Article 21)

FISHER (1958). As for the mechanism by which temperature acclimatization is effected, however, still there is a disagreements among opinions and the problem has not yet been settled.

The effect of ambient temperature is no doubt more direct on the protoplasm of every part of the body in poikilotherms than in homoiotherms. Thus, one of the orthodox ways to approach this problem is to push the analysis further down the levels of organization, namely, from the individual level to the organ, tissue and cellular levels. This direction of analysis has lately been growing in popularity. Another important way of approach is to keep under various conditions large numbers of animals, which are relatively small in size and easy to culture in the laboratory, and to observe precisely the influences of these conditions on the process of temperature acclimatization. Based on the results obtained, the mechanism of acclimatization is to be inferred. *Tigriopus* is certainly one of the most suitable experimental materials for the latter way of approach. In addition, the results of experiments with this material will perhaps be very interesting from the ecological point of view when they are considered in comparison to the peculiarities of its natural environment.

The present paper deals mainly with the processes of loss and gain of heat resistance in *Tigriopus* acclimated to different temperatures. The experimental results were partly published (MATUTANI 1960 a, b).

Materials and Culture Method

Experimental materials were all obtained from our laboratory stock cultures of *Tigriopus japonicus* MORI, which had originated from masses of individuals collected from the small pools near the Seto Marine Biological Laboratory, Sirahama, Wakayama Prefecture (Plate XVI) and had been maintained in our laboratory for at least 5 generations at 19°–20°C. *Tigriopus*, from hatching to maturity, passes through eleven stages which are divided into six nauplius stages and five copepodid stages. The 5th copepodid stage is followed by the adult stage. The distinction between sexes, which is very clear in the adult stage, appears first in the 4th copepodid stage (TAKEDA 1939).

The stock lines were cultured under fluorescent tubes in natural sea water which was carried from the Seto Marine Biological Laboratory. They received as food the marine alga, *Plectonema terebrans*, cultured in the laboratory and, in small amounts, powdered dry shrimp.

All the experiments were made with adult animals, 0.81–0.88 mm in body length, sampled at random from the stock cultures (Plate XVII 3 and 4). When they were exposed to a high lethal temperature, they became immobile at last bending upward their abdomens (Plate XVII 5 and 6). These individuals never recovered if returned to the normal temperature. Hence this response was adopted as the criterion of death for discriminating the dead from the alive in the experiments.

Experiment 1.

Change of heat resistance according to acclimation temperature in animals reared at 20°C

To begin with, the mode of change of heat resistance was investigated in animals which were transferred from a rearing temperature of 20°C to four different acclimation temperatures.

Materials and methods

From the stock of *Tigriopus japonicus* MORI which had been maintained in the laboratory for about 4 years after collection from Sirahama, adult animals were gathered and reared at 20°C (rearing temperature) for 45 days in glass cylinders, 93 mm in diameter by 50 mm high, containing 170 ml of sea water and placed under a 20 W fluorescent tube. They received the food once a day. From this 20° culture, adult animals were transferred to four different acclimation temperatures of 5°, 10°, 20° and 30°C, at which they were maintained in hemispherical glass bowls, 55 mm in diameter, containing 22 ml of sea water for definite lengths of time of 3, 6, 12, 24 and 48 hours before they were tested for their heat resistance (Fig. 1). They received no food in the acclimation temperatures.

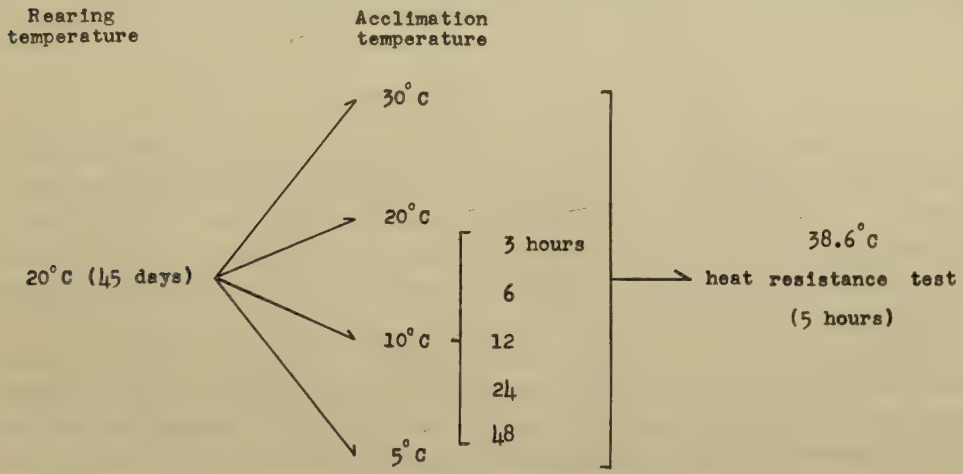


Fig. 1. Procedure of experiment 1.

The heat resistance test was conducted in the following way: Four test tubes, 15 mm in diameter by 160 mm long, containing 20 ml of sea water were immersed fully in a water bath controlled thermostatically at 38.6°C. After thermal equilibrium was established between the sea water in the test tubes and the water bath, about 100 individuals sampled at random from each temperature acclimation group were put in each test tube. The tubes were examined every hour till the 5th hour and the numbers of surviving individuals were recorded, picking out dead individuals every time.

In this way, about 2000 individuals were used for one series of tests. The experiment was repeated 5 times, and average values were calculated from the results of these experiments.

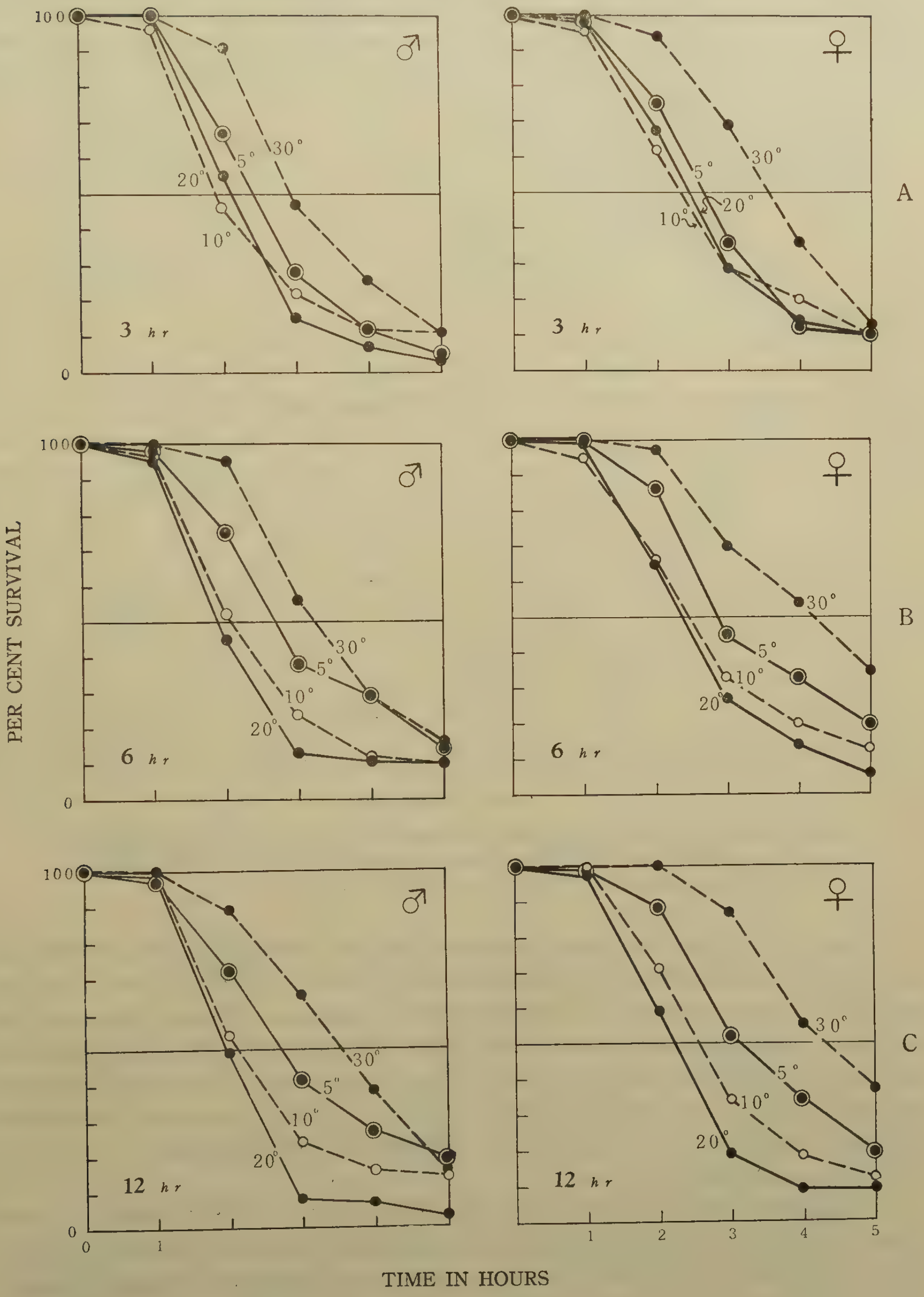
The temperature of 38.6°C at which heat resistance was tested was determined by a number of preliminary experiments. TAKEDA (1954) used 38°C for his heat resistance test on the same species. But this temperature was too low to conduct the heat resistance test efficiently and took so long time to detect differences among the acclimation groups that there was an increasing probability that the results of test might involve some side effects, such as the secondary temperature acclimatization and microbial interference during the test. The temperature of 38.6°C was found most appropriate, being neither too high nor too low to evaluate efficiently as well as exactly the net effect of acclimation.

Results and consideration

The results obtained are illustrated in Fig. 2 A–E. Fig. 2 A gives the time-survival curves at 38.6°C of animals acclimated from the same rearing temperature of 20° to four different temperatures for 3 hours. In both sexes, 30°–acclimated animals show the greatest heat resistance. Difference in resistance is slight among 5°–, 10°– and 20°–acclimated animals, their per cent survival curves sometimes crossing one another.

It is within 6 hours in acclimation (Fig. 2 B) that the differences in heat resistance among the four temperature groups become distinct and consistent. These differences grow larger with the duration of time of acclimation and the heat resistance of each group appears to reach a stationary state in 12 hours, though that of 20° group remains almost unchanged for 48 hours. The groups other than the 20°–acclimated show more or less marked gains in heat resistance. Thus they are eventually resistant to heat in the order: 30° > 5° > 10° > 20° of acclimation temperature, in both sexes.

These time-survival curves are very implicative representing the extents of individual variation in heat resistance. For the convenience to understand the mode of change of heat resistance with acclimation time, however, it is required to express the resistance of each acclimation group in terms of single index. For this reason, the sum of the survival percentages for 5 hours, *i.e.* the 5–hour cumulative per cent survival, was calculated and used as index of heat resistance. In such a case as the present, the median or 50% survival time is usually adopted. But this value was found to show a much larger extent of experimental fluctuation than the cumulative value. So the writer preferred the latter index to the former.


PER CENT SURVIVAL
100
0
♂
♀
3 hr
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5°
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TIME IN HOURS

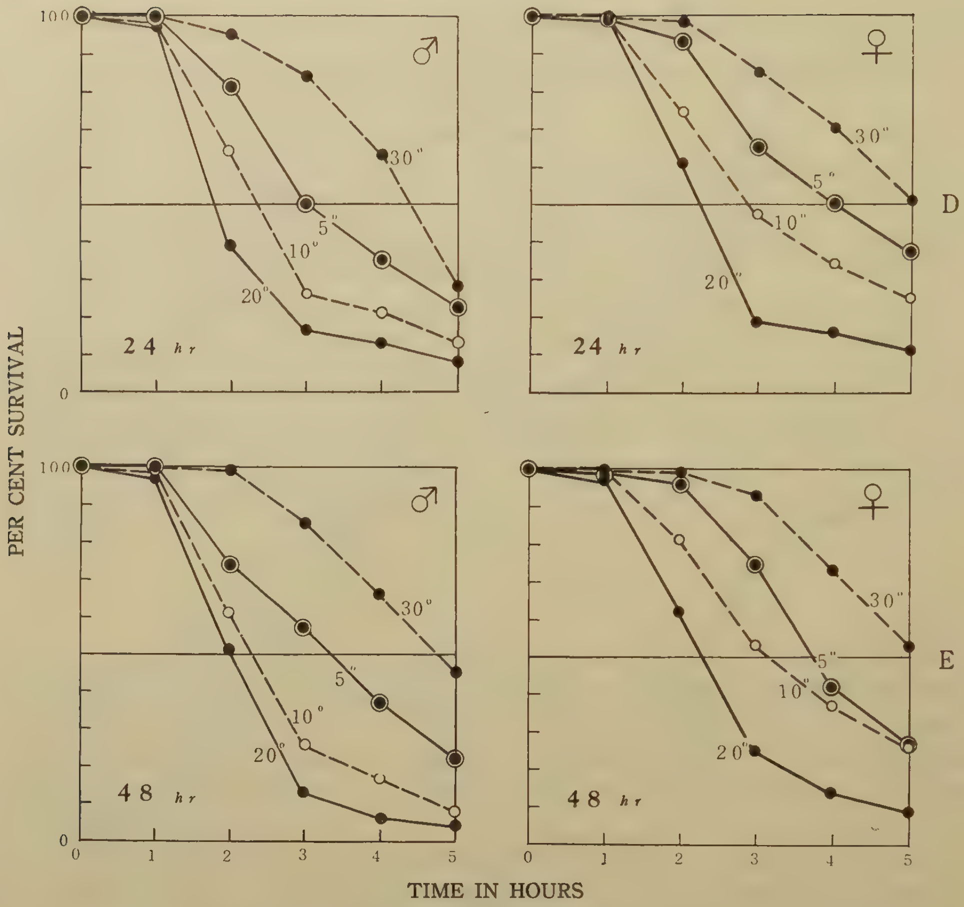

Fig. 2 (A–E). Time-survival curves at 38.6°C of adults of *Tigriopus japonicus* acclimated from the same rearing temperature of 20° to four different temperatures stated for given durations of time.

Change of the heat resistance in terms of 5-hour cumulative per cent survival in each acclimation group is shown in Fig. 3. There it is clearly seen that the control 20° group maintains its original level of resistance almost unchanged for 48 hours while the other groups which have been transferred to different acclimation temperatures other than 20° increase in resistance to varying extents within 24 hours. Thereafter they show only little, if ever, changes in resistance. It is evident from Figs. 2 and 3 that females are more resistant to heat than males in every case.

It deserves special attention that those groups which have been acclimated from their original rearing temperature of 20° to the temperatures other than this acquire heat resistance without exception, and that of the two groups acclimated to the lower temperatures the 5°-acclimated gains decidedly greater heat resistance than the 10°-acclimated does. This phenomenon is inconsistent with the general rule of temperature acclimatization acknowledged extensively among poikilotherms that a rise in acclimation temperature entails a gain in heat resistance and a loss in cold resistance while a fall in acclimation temperature results in the reverse (for crustaceans, Spoor 1955, Ranade 1957). This general rule is also found true in many cases of geographical and seasonal adaptation in heat resistance (for crustaceans, *e.g.* Bovjerg 1952, Krog 1954).

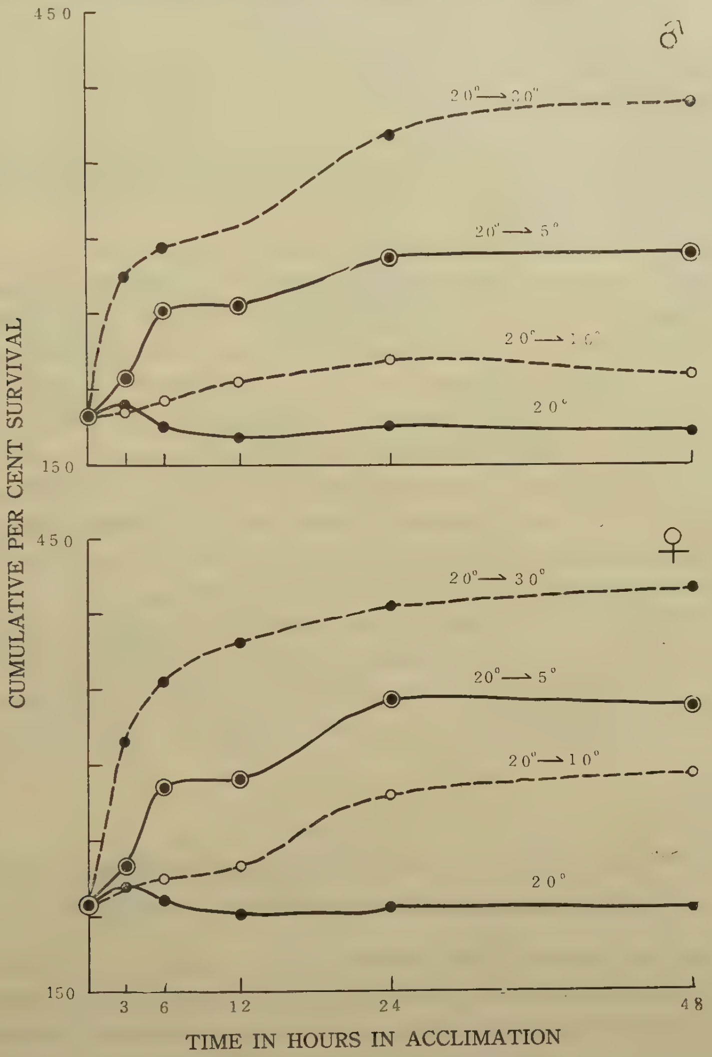

Fig. 3. Change of the heat resistance of adults of *Tigriopus japonicus*, as indicated by 5-hour cumulative per cent survivals at 38.6°C, with the duration of time after transfer from a rearing temperature of 20°C to four different acclimation temperatures.

In plants and poikilotherms other than crustaceans, however, there are a few examples of such a peculiar relation as has been shown in the present experiment (*cf.* PRECHT 1958). SAPPER (1935) has observed that cold-acclimated plants have not only high cold resistance but also high heat resistance. Dehydration appears to be involved in this case as one of the important factors. TSUKUDA and OHSAWA (1959) have shown in the fresh-water red snail, *Physa sp.*, that the heart rate of animals acclimated to 20° drops at higher temperatures than that of 25°-acclimated animals. HART (1952) has found in the fresh-water fish, *Micropterus salmoides*, that the northern race withstands higher temperatures better than the southern race. A similar phenomenon has been reported in the periwinkle, *Nodilittorina granularis* (OHSAWA and TSUKUDA 1956).

The phenomenon that *Tigriopus* gains heat resistance when it is acclimated from 20° to 30° may have some underlying mechanism in common with the phenomenon of temperature acclimatization generally observed in poikilotherms. It is, however, impossible to apply the same principle to the acquirement of heat resistance by *Tigriopus* acclimated from 20° to the lower temperatures. Here arise two important questions that have to be answered by further researches: Can a mere change in the environmental temperature, irrespective of its direction, induce an increase in heat resistance?; and, is the cause of the increased heat resistance the same in quality whether the environmental temperature is raised or lowered? The former appears improbable since, as has been reported (MATUTANI 1959), a respective higher level of resistance once acquired by *Tigriopus* that has been acclimated from 20° to another temperature is maintained as such as long as 240 hours. If heat resistance were gained through a stimulus which is nothing but a fall in the environmental temperature, it would be lost within a much shorter duration of time. The latter question requires a physiological approach.

Experiment 2.

Change of heat resistance according to acclimation temperature in animals reared at four different temperatures

The foregoing experiment has revealed a peculiar phenomenon that *Tigriopus* reared at 20° gains heat resistance when it is acclimated to 10° and 5° as well as when it is acclimated to 30°, giving a U-shaped acclimation temperature-heat resistance curve with a minimum resistance value at 20°. This phenomenon appeared to point to a possibility that the heat resistance of *Tigriopus* might increase, whether it was warmed or cooled, in function of, so to say, the absolute value of the difference between the rearing temperature and an acclimation temperature. To examine this possibility, animals reared at four different temperatures were acclimated respectively to four temperatures and the change of heat resistance was traced.

Materials and methods

Tigriopus was reared at 5°, 10° and 20° for 180 days and at 30°C for 30 days. It was found impossible to keep animals at 30° for a longer period than 30 days without any significant effect of selection. From these cultures adult animals were transferred to four acclimation temperatures of 5°, 10°, 20° and 30°C, at which they were maintained for 24 and 48 hours before they were tested for their heat resistance (Fig. 4). The culture of animals and the heat resistance test were made in the same way as described above.

About 3200 individuals were used for a series of tests, which was repeated 11 times, and average values were calculated from the results.

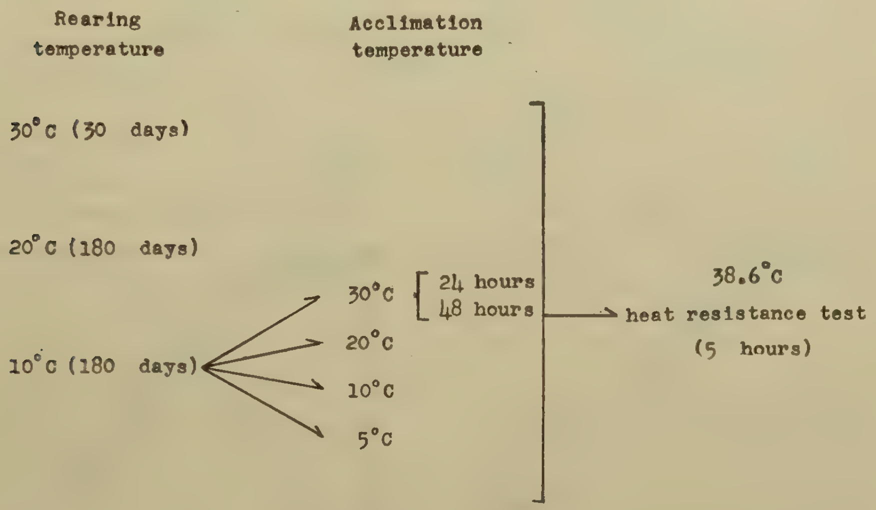

Fig. 4. Procedure of experiment 2.

Results and consideration

The results of the heat resistance test at 38.6°C are shown in Figs. 5 and 6. These time-survival curves show complicated relationships between the rearing temperatures and the acclimation temperatures. In 30°-reared animals, the original high level of heat resistance is well preserved for 24 hours after transfer to the lower temperatures, but in 48 hours they show some variation due to the acclimation to the altered temperatures. In 20°-reared animals, on the contrary, the change of heat resistance is most pronounced, the resistance rising rapidly when animals are transferred to the lower temperatures as well as when they are acclimated to the higher temperatures. The increase in resistance is rapid in the order of 30°, 5° and 10° acclimation. Among both 10°- and 5°-reared animals, the

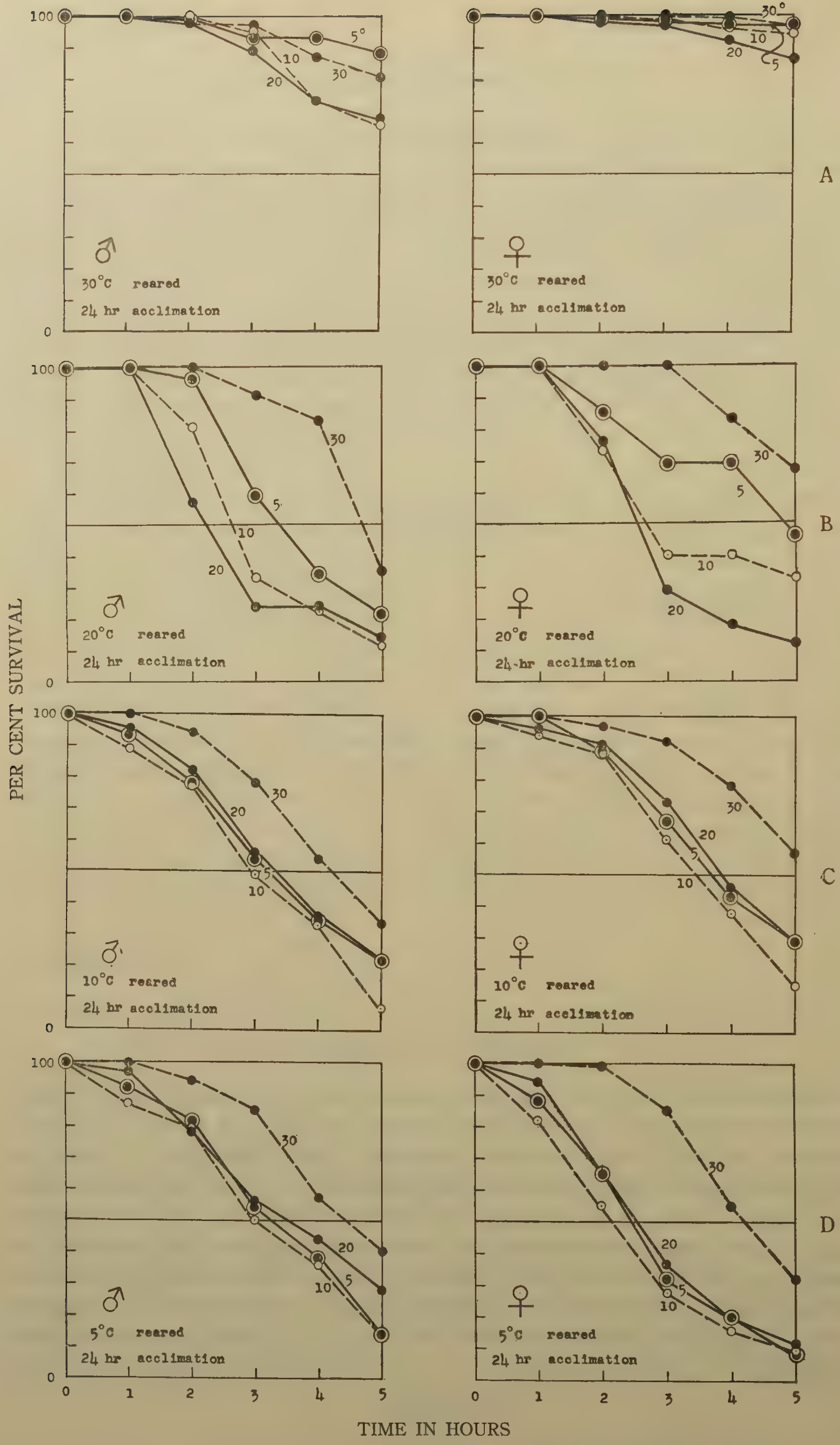

Fig. 5 (A–D). Time-survival curves at 38.6°C of adults of *Tigriopus japonicus* 24 hours after transfer from four different rearing temperatures to four different acclimation temperatures stated.

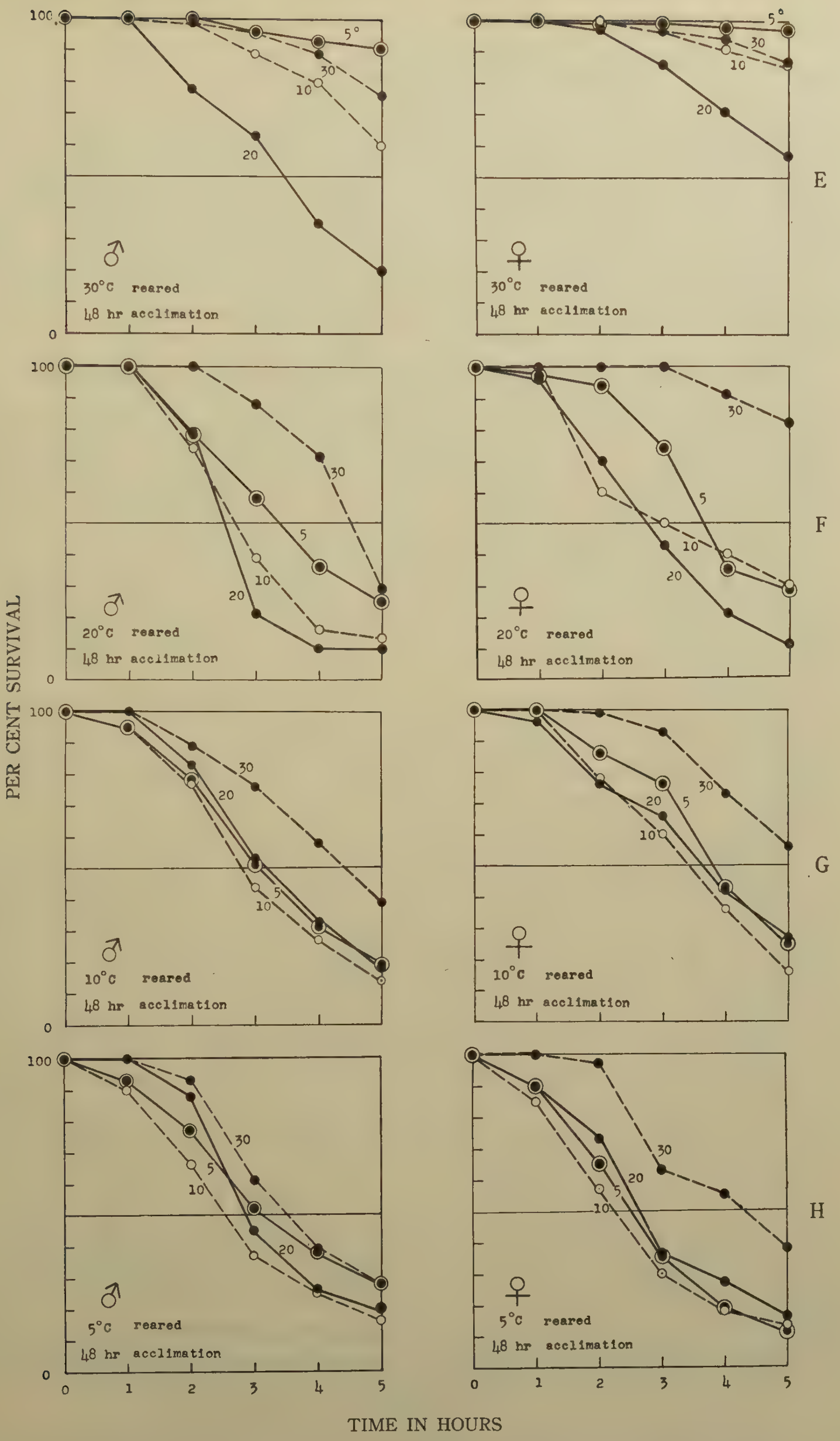

Fig. 6 (E–H). Time-survival curves at 38.6°C of adults of *Tigriopus japonicus* 48 hours after transfer from four different rearing temperatures to four different acclimation temperatures stated.

change of heat resistance due to acclimation is little significant except in 30° acclimation.

From each of these time-survival curves, the sum of per cent survivals for 5 hours, that is the 5-hour cumulative per cent survival, was calculated as the index of heat resistance for the convenience of ready comparison of the mode of change of heat resistance among the acclimations. The result is shown in Fig. 7, in which the indexes of resistance are plotted against acclimation temperatures.

These acclimation temperature-heat resistance curves are all characterized by the U-shape. In both 20°- and 30°-reared animals, the lowest resistance is shown in 20° acclimation. In 20°-reared animals, the highest resistance is attained by 30° acclimation group in both sexes, while in 30°-reared animals the resistance of 5° acclimation group appears somewhat higher than that of 30° acclimation group. In 5°- and 10°-reared animals, on the other hand, the highest resistance is shown in 30° acclimation and the lowest resistance in 10° acclimation. It is concluded, therefore, that 20°- and 10°-reared animals gain heat resistance whether they are warmed or cooled, while heat resistance is reduced as a result of temperature change when 30°-reared animals are acclimated to 20° and when 5°-reared animals are acclimated to 10°.

When *Tigriopus* is transferred from its rearing temperature to a different acclimation temperature, its heat resistance is considered to change gradually and to tend to a new stationary level which is proper to that acclimation temperature. On averages, the stationary level is higher in the order: $30° > 5° > 10° > 20°$ of acclimation temperature in males; and $30° > 10° > 20° > 5°$ in females.

The trend of heat resistance toward the stationary level in each case is illustrated in Fig. 8. Resistance increases rapidly in the animals warmed to 30° from the lower temperatures and decreases also rapidly in the animals cooled from 30° to 20°. The mode of change of resistance is, however, by no means simple. In some cases, a phenomenon of overshooting is acknowledged (Fig. 8 B, 5° acclimation; D, 10° acclimation), and in some cases resistance appears to be in a fairly stable state before it reaches the stationary level (Fig. 8 C, 20° and 30° acclimation; G, 30° acclimation). In other cases, resistance initially changes in the opposite direction to the stationary level (Fig. 8 A, 5° acclimation) and then returns back to the level (Fig. 8 D, 20° acclimation; F, 5° acclimation; G, 20° acclimation; H, 10° acclimation).

Heat resistance which, in most cases, is still changing 48 hours after transfer is supposed to reach eventually the corresponding stationary level when temperature acclimatization is completed. The time required for complete acclimatization will depend on the temperature of acclimation on the one hand and on the difference between the rearing and the acclimation temperature on the other. If, however, there has taken place some genetic variation associated with heat

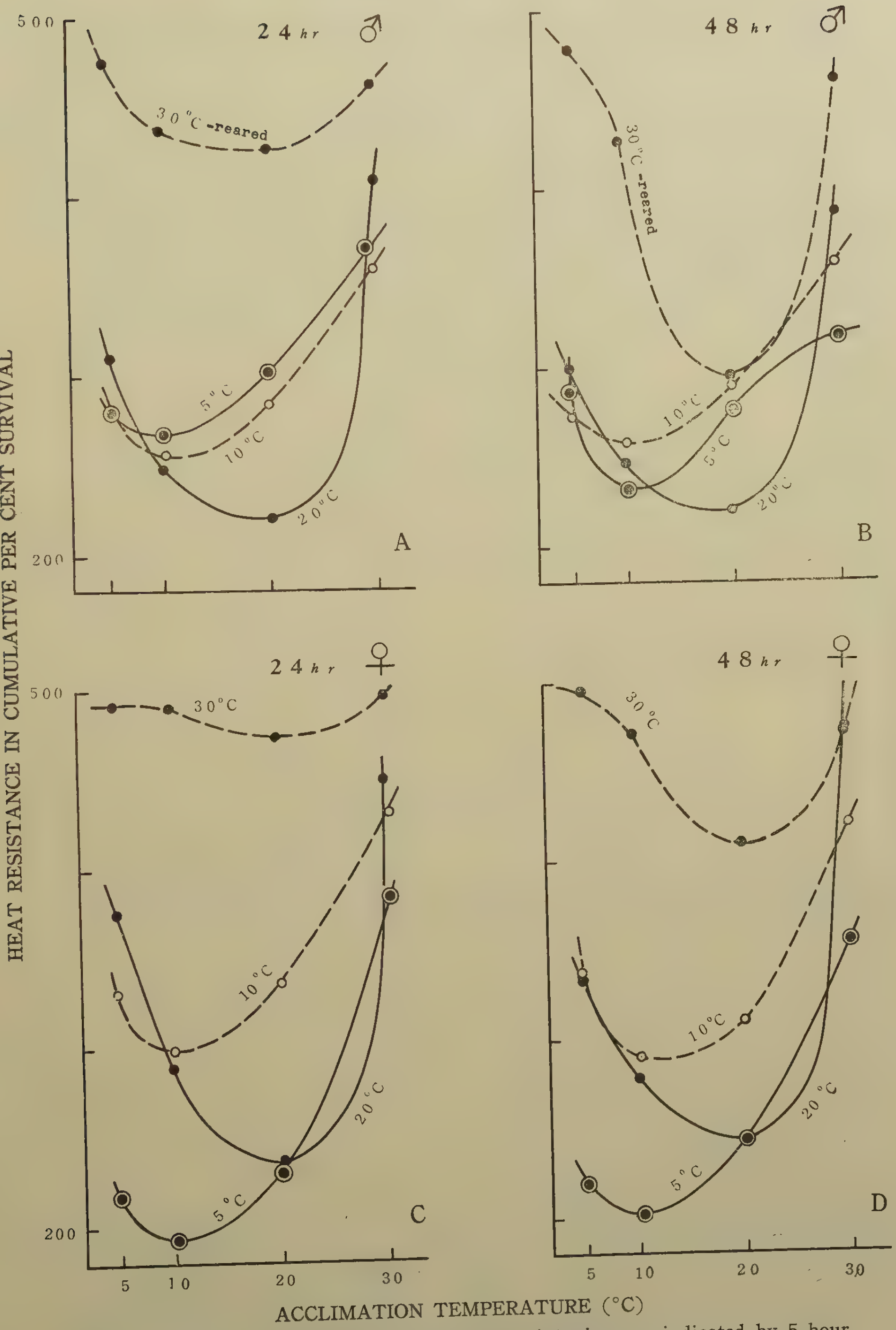

Fig. 7. Heat resistance of adults of *Tigriopus japonicus*, as indicated by 5-hour cumulative per cent survivals at 38.6°C, 24 and 48 hours after transfer from four different rearing temperatures stated to four different acclimation temperatures.

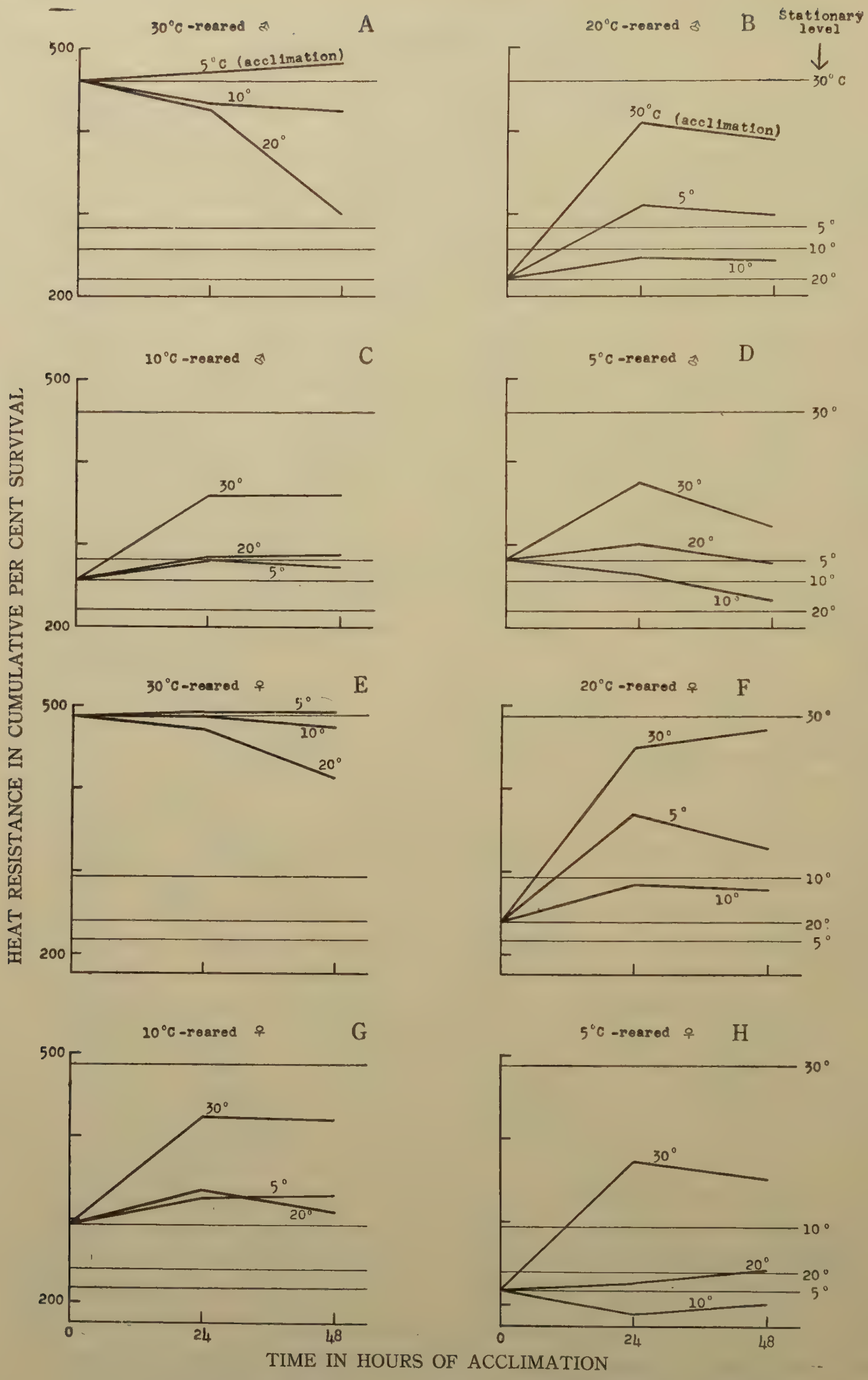

Fig. 8. Change of heat resistance of adults of *Tigriopus japonicus* as indicated by 5-hour cumulative per cent survivals at 38.6°C, 24 and 48 hours after transfer from the rearing temperatures, 5°, 10°, 20° and 30°C to four different acclimation temperatures stated. Fine horizontal lines indicate stationary levels of heat resistance to be reached when acclimatization is completed at the acclimation temperatures.

resistance in a temperature group of animals during the culture extending over several months, the stationary level may be different from that which is estimated.

Fig. 8 shows the absolute rate of change of heat resistance. Since the acclimation temperature–heat resistance curves are not linear and the stationary levels are not equally spaced, it may be necessary to take into consideration the relative rate besides the absolute rate of change of heat resistance. In this connection, Table 1 was made up in which the relative rate of change is given in percentages of the whole change from an original stationary level to a new stationary level to be reached when acclimatization is completed.

Table 1. Change of heat resistance of adults of *Tigriopus japonicus*, reared at four different temperatures, 24 and 48 hours after transfer to four acclimation temperatures, in percentages of the change from the original stationary level of heat resistance for a rearing temperature to the level for an acclimation temperature, and direction of change (arrows) to reach the latter level, negative signs showing changes reverse in direction to those indicated by arrows.

♂		Acclimation temperature (°C)							
		5°		10°		20°		30°	
		after 24 hr	after 48 hr	after 24 hr	after 48 hr	after 24 hr	after 48 hr	after 24 hr	after 48 hr
Rearing temperature (°C)	5°			↓ 63	↓ 174	↓ −33	↓ 8	↑ 52	↑ 22
	10°	↑ 100	↑ 74			↓ −86	↓ −86	↑ 51	↑ 51
	20°	↑ 138	↑ 120	↑ 72	↑ 66			↑ 79	↑ 71
	30°	↓ −6	↓ −11	↓ 15	↓ 19	↓ 14	↓ 66		

♀		Acclimation temperature (°C)							
		5°		10°		20°		30°	
		after 24 hr	after 48 hr	after 24 hr	after 48 hr	after 24 hr	after 48 hr	after 24 hr	after 47 hr
Rearing temperature (°C)	5°			↑ −38	↑ −19	↑ 57	↑ 119	↑ 57	↑ 50
	10°	↓ −46	↓ −46			↓ −88	↓ −34	↑ 68	↑ 66
	20°	↓ −619	↓ −428	↑ 85	↑ 72			↑ 84	↑ 93
	30°	↓ −2	↓ −2	↓ 0	↓ 7	↓ 6	↓ 31		

Fig. 8 and Table 1 show that the initial direction and the rate of change vary significantly according not only to acclimation temperature but also to rearing temperature. It was stated by a number of investigators (LOEB and WASTENEYS 1912, DOUDOROFF 1942, BRETT 1944, 1946) and is generally accepted that gain of heat resistance of poikilotherms in acclimation to higher temperatures is much more rapid than loss in acclimation to lower temperatures. The present data have many respects which contradict with this statement as the data obtained by TSUKUDA (1960) with the guppy, *Lebistes reticulatus*, have. The rule certainly holds good between 20° and 30° but does not over the whole range of temperature from 5° to 30°, which is conceivably due to the complicated relationship between acclimation temperatures and heat resistance such as represented by the U-shaped curves.

In the greenfish, *Girella nigricans*, DOUDOROFF (1942) observed an initial rise before gradual decline of heat resistance in fish acclimated from 26° to 14°. SPOOR (1955) also noticed a similar phenomenon in the crayfish, *Orconectes rusticus*, transferred from 22°–26° to 4°. Such initial rises are acknowledged in the present data, not only in acclimation to lower temperatures (Fig. 8 A and E, 5° acclimation; F, 5° acclimation; G, 5° acclimation) but also in the case of loss of heat resistance in acclimation to higher temperatures (Fig. 8 C, D and G, 20° acclimation).

Experiment 3.

Cyanide resistance of *Tigriopus japonicus* in relation to acclimation temperature

The resistance to cyanide of *Tigriopus* acclimated to different temperatures was tested to see whether there are or there are not physiological differences other than that in heat resistance between the individuals which have gained heat resistance through acclimation to a high temperature of 30° and those which have become resistant to heat through acclimation to low temperatures of 10° and 5°.

Materials and methods

Tigriopus was kept in a mass at 19°C for 30 days. From this culture adult animals were transferred to four different acclimation temperatures of 2°, 9°, 19° and 28°C, at which they were maintained for 4, 20 and 46 hours, in the same way as described above, before they were tested for their resistance to cyanide. The test was made by keeping them by 100 individuals in a hemispherical glass bowl, 55 mm in diameter, containing 22 ml of M/20 NaCN sea water at 19°C, for 2 hours during which mortalities were recorded every 15 minutes (Fig. 9).

Results and consideration

From each time-per cent survival curve obtained, the 2-hour cumulative per cent survival, *i.e.*, the sum of survival percentages observed every 15 minutes for 2 hours, was computed as in the case of the heat resistance test described in the foregoing chapters. Using this value as the index of cyanide resistance, the acclimation temperature-cyanide resistance curves were drawn (Fig. 10).

These curves indicate that there are pronounced differences in cyanide resistance among the four temperature acclimation groups, which vary significantly with time. After 4 hours in acclimation, the lower the acclimation temperature, the greater is cyanide resistance. Then cyanide resistance increases relatively rapidly with time in 28°-acclimated animals, while it decreases appreciably in 9°-acclimated males and 2°-acclimated females. In 20°-acclimated males and 9°-acclimated females, however, the decreasing change of cyanide resistance is little significant.

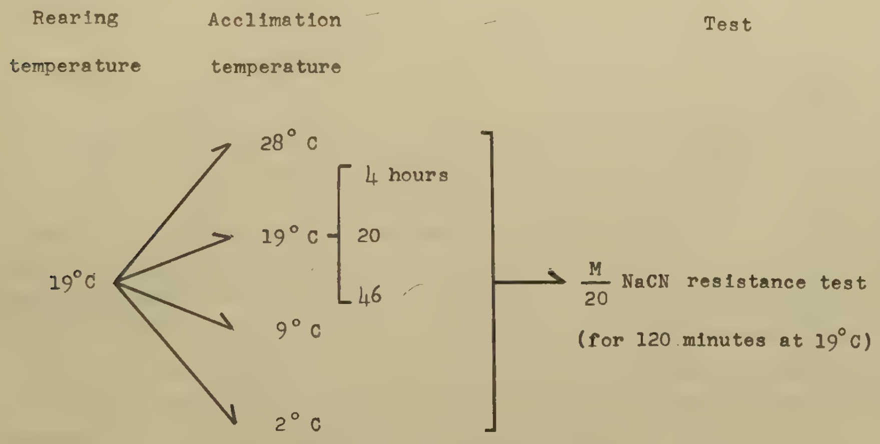

Fig. 9. Procedure of experiment 3.

Since cyanide inhibits oxidative processes, a high level of cyanide resistance is considered as indicating primarily a depressed activity of aerobic metabolism, which in turn is perhaps associated with a reduced rate of oxygen consumption. It is a well established fact that the rate of oxygen consumption of poikilotherms decreases with falling temperature within the normal range of temperature (for crustaceans, *c.f.* Marshall and Orr 1955; also see Bullock 1955, Fry 1957, Precht 1958), and it has also been demonstrated by many investigators (Sayle 1928, Kirberger 1953, Blazka 1955, Kanungo and Prosser 1959) that temperature acclimation has usually a compensatory effect on the rate of oxygen consumption.

When animals acclimatized completely to 19° are transferred from this rearing temperature to 2°, they become considerably inactive, remaining almost immobile at the bottom of vessel, probably, in a state of chill coma. In this state, their metabolism is supposed to be extremely depressed. Those individuals which have fallen into such a state do not restore readily their activity after they are returned back to 19°. If, however, they are kept longer at 19°, their activity recovers to some extent owing to 'capacity adaptation or acclimatization' (Precht 1958). In fact, some of 2°-acclimated animals were observed to swim slowly 2–3 days after transfer. The gradual decrease of cyanide resistance in 2°-acclimated females (Fig. 10) certainly indicates the effect of capacity acclimatization in aerobic metabolism. In males, the effect is far less explicit in 2° acclimation than in 9° acclimation.

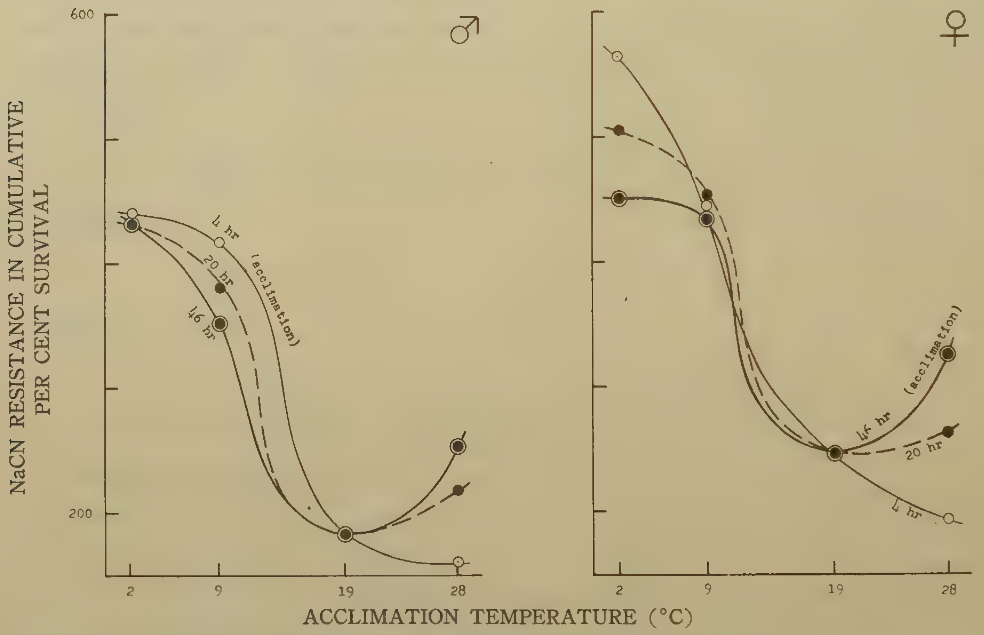

Fig. 10. Cyanide resistance of adults of *Tigriopus japonicus*, 4 (empty circles), 20 (solid circles) and 46 (double solid circles) hours after transfer from a rearing temperature of 19°C to four different acclimation temperatures. Cyanide resistance is indicated by 2-hour cumulative per cent survivals in M/20 NaCN sea water at 19°C, observed at intervals of 15 minutes.

When, on the other hand, 19°-reared animals are transferred to 28°, their activity increases. Very low values of cyanide resistance for individuals acclimated to 28° for 4 hours reflect the activated state of aerobic metabolism. Here also capacity acclimatization is evidently acknowledged in individuals acclimated to 28° for prolonged periods. The appreciable gains in cyanide resistance in 28° acclimation indicate such a compensatory effect.

Comparing the result obtained by this experiment with those obtained by the foregoing, some parallelism is perceived between cyanide resistance and heat resistance over the range of acclimation temperature from 2° to 19°. But the relation cannot be applied to 28° acclimation in which cyanide resistance is still far lower than that in 9° acclimation even after 48 hours while the heat resistance of 30°-acclimated animals exceeds that of 5°-acclimated animals within 24 hours of acclimation (Figs. 7 and 10). SUMNER and DOUDOROFF (1938) have shown that fish acclimated to 30° are more resistant to cyanide, urethane and oxygen lack than those acclimated to 10° when compared at 20°. This relationship suggesting a reduced oxygen requirement as a result of acclimation to the high temperature agrees with that observed between 19° and 28° but does not with that observable among the temperatures lower than 19° in the present data.

The results obtained show that there are more or less distinct differences in aerobic metabolism between animals acclimated to 2° and 9° and those acclimated to 28°, and suggest that the acquirement of heat resistance at the low acclimation temperatures is different in mechanism from that at the high acclimation temperatures.

Experiment 4.

Temperature acclimatization in the heat resistance of *Tigriopus japonicus* in relation to environmental oxygen concentration

The preceding experiment has indicated a high degree of probability that the acquirement of heat resistance at the low acclimation temperatures is caused by the inactivation of aerobic metabolism due to cooling. This suggests a possibility that if the metabolic activity of animals is depressed by some agent other than coldness, they will also gain heat resistance. To examine this possibility, *Tigriopus* was acclimated to 20° and 30° in high and low concentrations of oxygen.

Materials and methods

Adult animals of *Tigriopus* sampled at random from the 20° culture were put by 100 individuals into a test tube, 30 mm in diameter by 195 mm long, containing 85 ml of sea water of a given oxygen saturation at an acclimation temperature of 20° or 30°. The test tube thus prepared was immediately closed with a rubber stopper and kept at that acclimation temperature for 35 or 59 hours before the animals were tested for their heat resistance in the same way as was described previously. The apparatus used for controlling the oxygen concentration in acclimation sea water is schematically illustrated in Fig. 11. To decrease the concentration of oxygen in sea water nitrogen gas flowed through the tubing *L* was bubbled into sea water in the equilibration tank *B* which was immerged into a water bath *A* controlled thermostatically at a given temperature. The flux of nitrogen gas was measured by a graduated cylinder *F* and was controlled by cocks. Sea water was sampled at times from the tank *B* through the tubing *C* and the oxygen concentration was examined by the Winkler method. When the latter was decreased to a required level, sea water was introduced into the test tube for acclimation *K* which had been filled with nitrogen gas at the acclimation temperature. To obtain sea water of high oxygen saturations, aerated sea water piped from the reservoir *E* was kept in the tank *B* for about 24 hours without bubbling in thermal equilibrium with the water bath *A*. Thus, high and low levels of oxygen concentration were prepared for either acclimation temperature (Fig. 12).

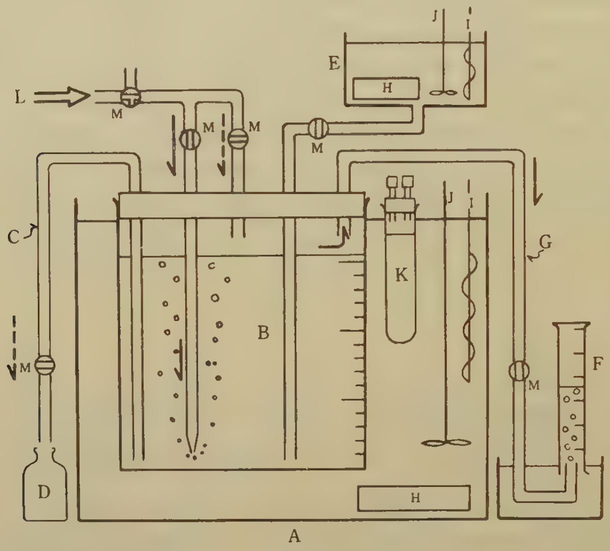

Fig. 11. Schematic diagram of the apparatus to obtain sea water of a given level of oxygen concentration.

A : thermostatic water bath.
B : sea water tank for equilibration of temperature and of nitrogen gas.
C : glass tubing for drawing out sea water from the tank.
D : Winkler flask.
E : reservoir for supplying sea water.
F : graduated cylinder for measuring the flux of nitrogen gas.
G : glass tubing for gas exhaust.
H : heater.
I : regulator.
J : stirrer.
K : test tube for acclimation.
L : inlet for nitrogen gas.
M : cocks.

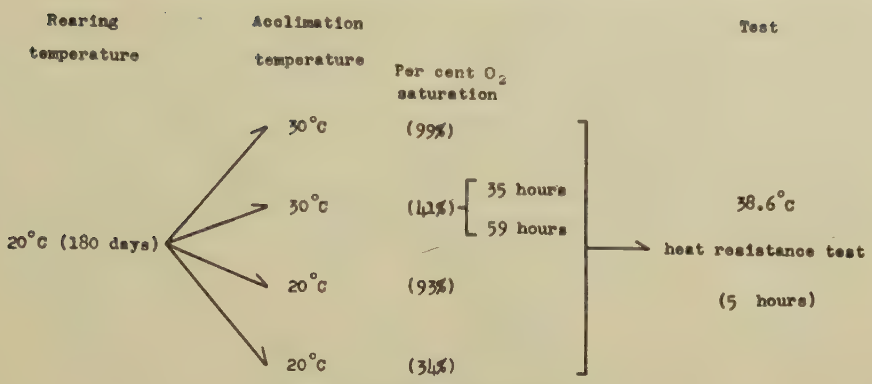

Fig. 12. Procedure of experiment 4.

Results and consideration

The results obtained are shown in Fig. 13 A and B in the time-survival relations, from which it is obvious that 30°-acclimated animals are by far more resistant to heat than 20°-acclimated ones and that animals acclimated at low levels of oxygen saturation are always significantly more heat resistant than those acclimated at high levels.

Brett (1944, 1946) found in the bullhead, *Ameiurus nebulosus*, that a continuous low oxygen saturation of the water in the acclimation tank inhibited acclimatization to heat up to 23 hours. Namely, fish acclimated from 20° to 28° in adequate oxygen saturation which ranged from 64 to 74% appeared to have completed virtually temperature acclimatization within 23 hours, while those acclimated from 17° to 27° in very low oxygen saturation which ranged from 2 to 26% showed a distinct lack of acclimatization. He considered that oxygen played some positive role in the mechanism of heat acclimatization. His findings apparently conflict with the present results. It must be noticed, however, that the level of insufficient oxygen adopted by Brett is extremely low in comparison with that used in the present experiment and that the level of sufficient oxygen adopted by him is also markedly low. Exact comparison is, therefore, impossible between the two data. In *Tigriopus*, the acclimation in 10.7% O_2 saturation was found impracticable causing 22 to 35% mortalities, though the acclimation in 34% or 41% O_2 brought about no ill effect. Superposing the present data on the Brett's, it would be suggested that there might be an optimal O_2 concentration for temperature acclimatization to take place. But, this conception should be evaluated by a further investigation.

At all events, *Tigriopus* appears to be relatively sensitive to oxygen deficiency, and its aerobic metabolism is supposed to be suppressed not a little in such low levels of oxygen as 34% and 41%. This inactivated state must have some

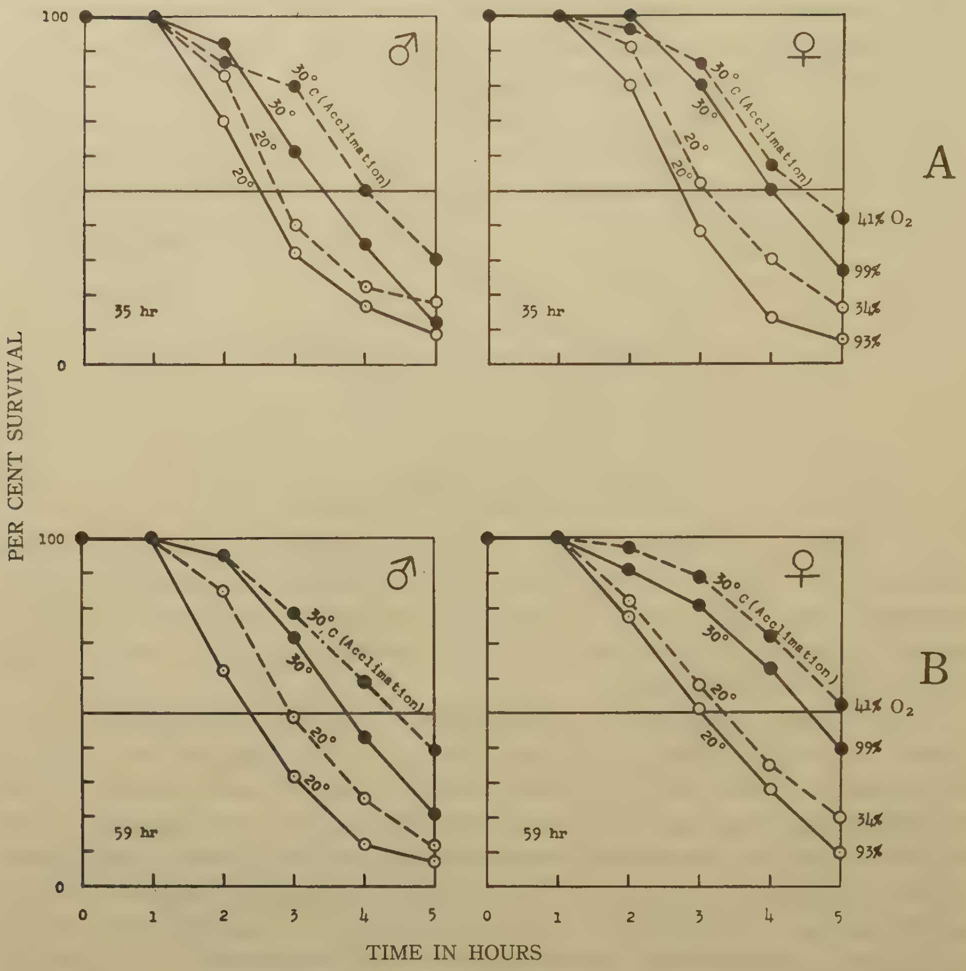

Fig. 13 (A–B). Time-survival curves at 38.6°C of adults of *Tigriopus japonicus* acclimated to 20° (empty circles) and 30°C (solid circles) for 35 and 59 hours at high (solid lines) and low (broken lines) levels of O_2 saturation.

favorable effect on the heat resistance of animals in the subsequent exposure to a high temperature.

Experiment 5.

Heat resistance in relation to salinity, of *Tigriopus japonicus* acclimated to dilute and concentrated sea waters

The foregoing series of experiments has been focused on the mechanism through which *Tigriopus* gains heat resistance when it is warmed or cooled from its optimal temperature. Viewed from such a standpoint, the present experiment is rather secondary in nature. As already mentioned, salinity is without doubt an environmental factor for *Tigriopus* no less important than temperature. It is expected that the former is closely associated with the latter in their effects on the physiology of *Tigriopus* as it is in their fluctuations in the natural environment of this species. So it is highly interesting not only from the physiological viewpoint but also from the ecological viewpoint to see how the heat resistance of this species is related with ambient salinity.

Materials and methods

Adults of *Tigriopus japonicus* from the culture in 100% sea water (18.46‰ Cl) at 20°C were acclimated to 25% and 150% of sea water for definite periods of time as shown in Fig. 14. Then they were tested for their heat resistance, as described above, in various per cent concentrations of sea water (Fig. 14). The concentrations used for either salinity acclimation group were within the range of concentration to which *Tigriopus* could be transferred without deleterious effects at 20°C (MATUTANI, unpublished data).

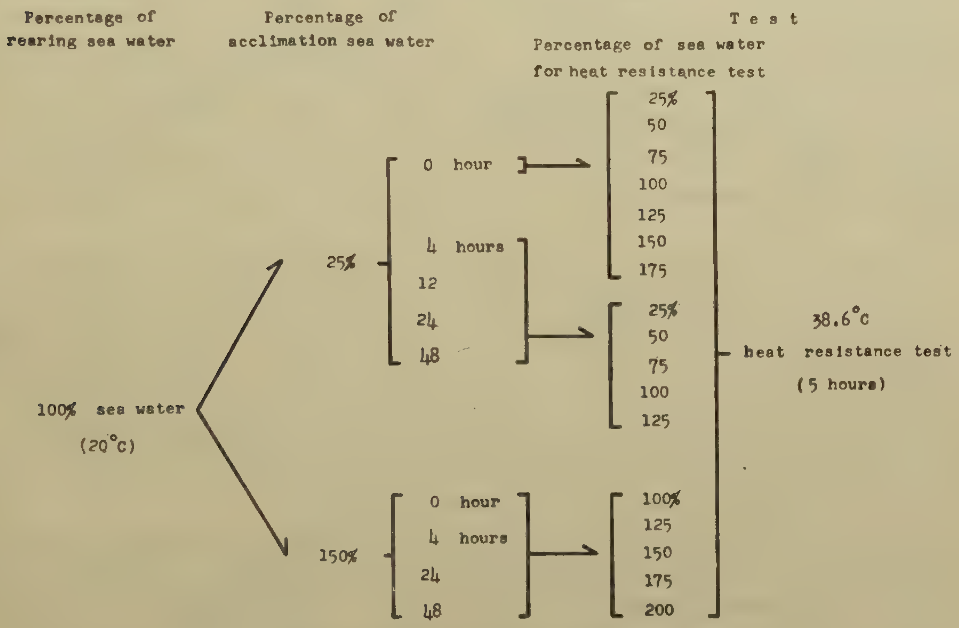
Percentage of rearing sea water
Percentage of acclimation sea water
Test
Percentage of sea water for heat resistance test
100% sea water (20°C)
25%
0 hour
4 hours
12
24
48
150%
0 hour
4 hours
24
48
25%
50
75
100
125
150
175
25%
50
75
100
125
100%
125
150
175
200
38.6°C
heat resistance test
(5 hours)

Fig. 14. Procedure of experiment 5.

Various concentrations of sea water were obtained by diluting 200% sea water, which was prepared by evaporation at a temperature below 40°C, with fresh water purified by ion exchange.

Results and consideration

For the convenience of comparison, the values of heat resistance, expressed in 5-hour cumulative per cent survivals, are plotted against the per cent concentration of test sea water in Figs. 15 and 16.

The 0 hour curves *i.e.* curves for the control 100%-acclimated animals have their apexes at 150% without exception and are almost symmetric in shape falling down gradually on either side of this concentration. When animals are acclimated to 25% sea water, their heat resistance markedly decreases on the whole with the duration of acclimation time and at the same time the concentration in which they show the highest resistance to heat becomes lower (Fig. 15). After 48 hours of acclimation, the maximum resistance is given at 50% in males and at 75% in females. In 150%-acclimated animals, on the other hand, heat resistance increases pronouncedly within 24 hours of acclimation and then it decreases to some extent (Fig. 16). After 4 hours, the increase in resistance is much larger on the higher concentration side of 150% than on the lower side. After 24 hours, curves become much flattened, especially in females, and the concentration in which resistance is highest is found shifted to 175% from 150%. After 48 hours, however, resistance falls appreciably on the higher side in males and on both lower and higher sides in females, though it is well preserved in 150% in both sexes.

There are not a few cases reported with various animal forms and with different levels of organization in which heat resistance is higher in hypertonic media than in isotonic or hypotonic media. This is the case, for example, with the frog muscle (Vernon 1899), *Paramecium* (Hutchinson 1913, 1915) and the periwinkle, *Nodilittorina granularis* (Ohsawa and Tsukuda 1956). There is however an optimum salinity, for 100% sea water-acclimated animals to withstand heat, at about 150% sea water, above which resistance decreases. Tokioka and Suzuki (1939) reported the similar tendency.

The phenomenon that the heat resistance of marine invertebrates increases with the salinity to which they are acclimated has also been observed by some authors. Thus, Kinne (1958) has shown that the heat resistance of the polychaete, *Nereis diversicolor*, the amphipod, *Gammarus duebeni*, and the isopod, *Sphaeroma hookeri*, is lowered in low salinity-adapted animals and raised in high salinity-adapted animals. According to his view, one cause for the shift of heat resistance is obviously the alteration of water and ionic balance in animals under stress. It is likely that dehydration is involved in this phenomenon, which can increase general protoplasmic resistance to extreme temperatures (Precht 1958).

There is at present no information available on the osmotic relation of *Tigriopus* to its medium, though there are detailed studies on the osmotic regulation of *Gammarus* (Beadle and Cragg 1940) and *Artemia* (Croghan 1958 a, b).

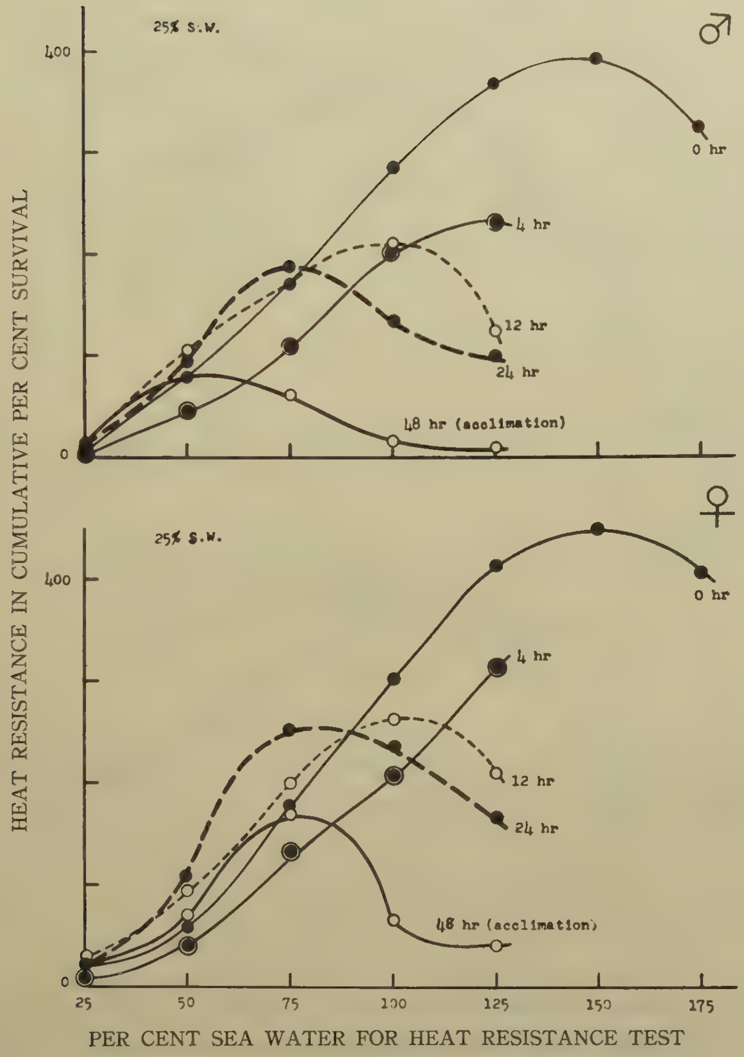

Fig. 15. Heat resistance in various per cent concentrations of sea water of adults of *Tigriopus japonicus* acclimated from a rearing concentration of 100% to 25% sea water at 20°C for definite lengths of time from 4 to 48 hours. Heat resistance is indicated in 5-hour cumulative per cent survivals at 38.6°C.

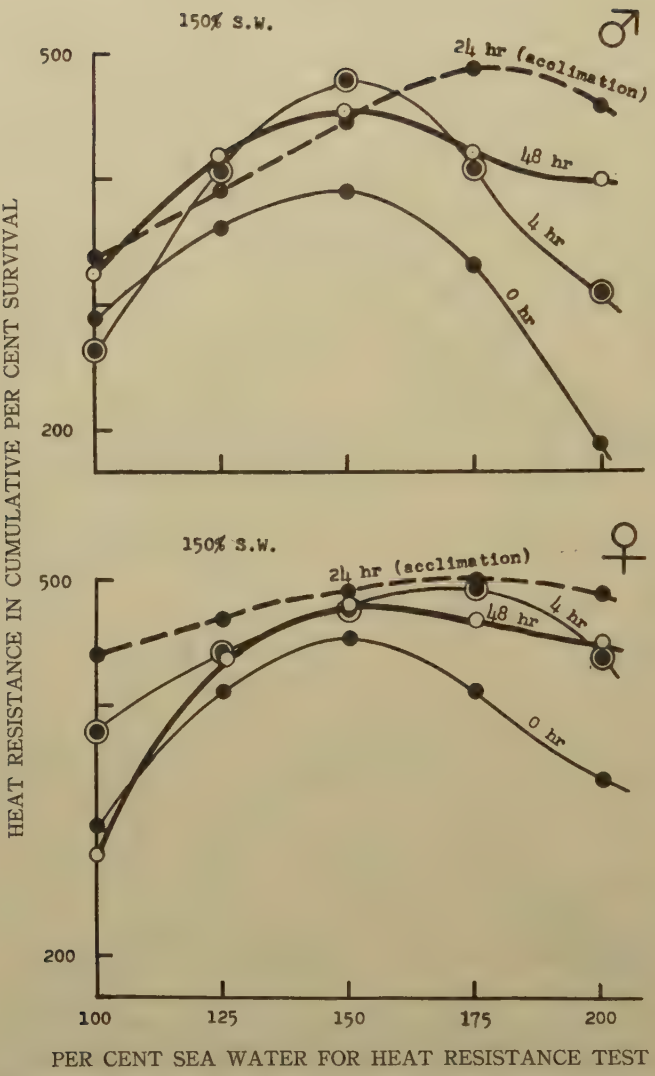

Fig. 16. Heat resistance in various per cent concentrations of sea water of adults of *Tigriopus japonicus* acclimated from a rearing concentration of 100% to 150% sea water at 20°C for definite lengths of time from 4 to 48 hours. Heat resistance is indicated in 5-hour cumulative per cent survivals at 38.6°C.

The relatively rapid decrease of the optimum salinity for heat resistance in 25% sea water-acclimated animals and the little increase of the optimum salinity in 150% sea water-acclimated animals appear to indicate that the ability of osmotic regulation of this species is comparatively low in the hypotonic medium and high in the hypertonic medium. But there is no reason to regard the shift of the optimum salinity as reflecting the osmotic property of animals. It is, nevertheless, indubitable that *Tigriopus* is euryhaline, a fact which suggests a high degree of probability that it possesses a somewhat evolved osmoregulatory function in comparison with its pelagic relatives. At any rate, the explanation of the phenomena observed must wait for further experiments.

Apart from the consideration on the underlying physiological processes, the relations obtained by the present experiment are very suggestive from the ecological point of view. Tide pools inhabited by *Tigriopus* are situated well above the high tide mark and rarely overflowed by waves unless the sea is raging. Sea water in such tide pools are readily concentrated by evaporation or diluted with rain water. Ordinarily, an extreme elevation of water temperature under the direct sun in summer months is accompanied with accerelated concentration by evaporation. The increase of heat resistance in a hypertonic medium is certainly advantageous for the life of *Tigriopus*. On the other hand, a rapid elevation of water temperature after a heavy rain, if it occurs, will constitute a crisis.

Discussion

The present study was undertaken for the purpose of elucidating the process of temperature acclimatization in the heat resistance of the eurythermal copepod *Tigriopus japonicus*. Exp. 1 revealed an unexpected phenomenon that heat resistance was gained not only by animals acclimated from 20° to 30° but also by those acclimated from 20° to lower temperatures. This finding has orientated the subsequent study in the direction of investigating the mechanism of acquisition of heat resistance in low temperature acclimation in comparison with that in high temperature acclimation.

The possibility that a change in the ambient temperature, whether upward or downward, might alone induce an increase in heat resistance has been denied by Exp. 2, which showed that heat resistance was markedly reduced in many cases, when the ambient temperature was changed, *e.g.*, from 30°to 20° and from 5° to 10°.

Then it has remained as the most important problem whether the mechanism underlying the acquisition of heat resistance in low temperatures is or is not the same in nature with that in high temperatures. Animals acclimated to 5° or 10° appear to be so different in their general physiological conditions from those acclimated to 30° that it is quite unlikely that the mechanisms should be the same. The former are in a state like chill coma for some time after transfer, while the latter show much increased activity. Phenomenally it can be said that inactivation at low temperatures and activation at high temperatures bring about the same result which is the gain of heat resistance. Those relations seem to diminish very much the probability that heat resistance is gained through the same process in low temperature-acclimated animals and in high temperature-acclimated animals.

The working hypothesis preferred is that the acquisition of heat resistance at low temperatures is effected secondarily by the inactivation of general metabolism of animals and is accordingly altogether different in mechanism from that at high temperatures which is temperature acclimatization in the strict sense of the term. Temperature acclimatization in this sense is observable in many poikilotherms and may involves some fundamental alterations in their physiological properties. On the other hand, it is a problem difficult to interprete how the inactivation of metabolism causes the gain of heat resistance. A solution of the problem has perhaps to be pursued in the mechanism of heat death.

Concerning the mechanism of heat death, there are a few theories, none of which is decisive. The mechanisms may be different with different high temperatures at which resistance is tested and with different conditions of the resistance test. An important theory is that death at high temperatures is asphyxial (*cf.* FISHER 1958). Since the test temperature of 38.6°C is relatively low for a high lethal temperature, it seems more probable that on transfer to this temperature the metabolic rate of *Tigriopus* is elevated immediately up to the limit beyond which oxygen deficiency in tissues has a fatal effect than that the thermal alteration of body substances takes place in tissues. If the heat death of *Tigriopus* is asphyxial in the present case, the heat susceptibility of animals is directly related to their oxygen requirement at the test high temperature.

According to the experience of the writer, the optimum temperature for *Tigriopus* is 20° or thereabout. Hence animals acclimated to 20° are considered to have their physiological activities in most harmonized and efficient conditions. If such animals are put at the test temperature, their metabolic rate is accerelated extremely till at last heat death occurs. In animals acclimated to 30° the metabolic activity becomes decreased through temperature acclimatization and, when exposed to the test temperature, it does not rise so high as in 20°-acclimated animals. This contributes to heat resistance. On the other hand, when animals are acclimated to low temperatures such as 5° and 10°, their metabolic activity becomes considerably suppressed, and, on transfer to the test temperature, metabolic rate is elevated far less readily in them than in 20°-acclimated animals. This results in an increased level of heat resistance.

Thus, it is inferred that so far as the range of temperature is concerned within which the acclimation experiments have been carried out, the higher the acclimation temperature, the greater is the effect of temperature acclimatization and the smaller is the effect of metabolic inactivation. Both effects would result jointly in the U-shaped acclimation temperature-heat resistance curves.

This theory finds strong support in the results obtained by Exp. 3 and also in the results by Exp. 4. The increased cyanide resistance in animals transferred to 20° from the lower acclimation temperatures at the early period of acclimation indicates the inactivated state of aerobic metabolism in these animals, and the decreased cyanide resistance in animals transferred from the higher temperature the activated aerobic metabolism in them. Temperature acclimatization presents itself as an effect to reduce the differences in cyanide resistance.

In this case, however, cyanide-insensitive metabolism cannot be neglected. There is evidence suggesting the alteration of metabolic pattern as a result of acclimatization to temperature (EKBERG 1958) as in the case of acclimatization to oxygen (PROSSER *et al.* 1957). After EKBERG, cold-acclimated goldfish depend relatively more on an active cyanide-sensitive path and warm-acclimated ones on an iodoacetate-sensitive path. There is, however, no information available at present on the cyanide-insensitive metabolism of *Tigriopus*. The problem is open for further study. The acquirement of heat resistance by animals acclimated to low oxygen can also be interpreted as resulting from the inactivation of aerobic metabolism under the condition of oxygen deficiency.

A dualistic conception about the mechanism of acquirement of heat resistance in *Tigriopus* has been concluded from the results of the present series of experiments. It is not clear whether this conception is restricted to *Tigriopus* or applicable to other poikilotherms. There is a possibility that such phenomena as have been observed in *Tigriopus* may be found in other forms if acclimation experiments are performed over relatively wide ranges of temperature, since, in *Tigriopus*, only simple relations showing the ordinary effect of temperature acclimatization would have been obtained if acclimation had been confined within a narrow range of temperature, say, from 20° to 30°.

Summary

Change of heat resistance was investigated in relation to the environmental temperature and salinity with the euryplastic microcopepod, *Tigriopus japonicus*, which inhabits tide pools situated well above the high tide mark. Heat resistance was tested by exposing animals to 38.6°C for 5 hours and determining the mortality every hour in definite lengths of time after acclimation to various conditions.

1. When animals from 20°-reared culture were acclimated to four different temperatures of 5°, 10°, 20° and 30°C, the highest heat resistance is shown by 30°-acclimated individuals and the lowest resistance by 20°-acclimated ones, those

acclimated to 5° being next to the former in resistance. Thus U-shaped acclimation temperature-heat resistance curves result in either sex over the range from 5° to 30°C.

2. When animals which have been reared at four temperatures of 5°, 10°, 20° and 30° are respectively transferred to the four acclimation temperatures, also U-shaped acclimation curves are obtained in each case. Heat resistance is lowest in 10° acclimation for 5°- and 10°-reared animals and in 20° acclimation for 20°- and 30°-reared animals. In 30°-reared animals, 5° acclimation results in a slightly greater resistance than 30° acclimation. The results disproves the possibility that a change in the environmental temperature alone may induce a gain of heat resistance. Moreover, they show the relations which contradict with the well-established principle of temperature acclimatization that heat resistance is gained much more rapidly on warming than it is lost on cooling.

3. In 20°-reared animals, the lower the acclimation temperature, the higher is the resistance to cyanide when tested at 20°. This suggests that aerobic metabolism is inactivated in acclimation to lower temperatures and activated in acclimation to higher temperatures so that it does not restore readily its original level on returning to 20°. Cyanide resistance somewhat decreases gradually with time in 5° and 10° acclimation and increases in 30° acclimation, conceivably owing to the effect of true temperature acclimatization.

4. Those animals whose respiration has been suppressed for 35 and 59 hours in reduced oxygen concentrations, *i.e.* 34% oxygen in 20° acclimation and 41% oxygen in 30° acclimation, prove appreciably increased heat resistance in comparison to those which have been kept in sufficient concentrations of oxygen, *i.e.* in 93% oxygen in 20° acclimation and 99% oxygen in 30° acclimation.

5. Heat resistance changes markedly with the salinity of acclimation sea water as well as with the salinity of test sea water. The heat resistance of the control, *i.e.*, 100% sea water-acclimated animals is highest in 150% sea water and declines gradually whether the concentration of test sea water is decreased or increased. In 25% sea water-acclimated animals, heat resistance falls rather rapidly with time and the concentration of test sea water in which they are most resistant to heat moves toward lower concentrations till it reaches 50% after 48 hours of acclimation. In 150%-acclimated animals, on the other hand, heat resistance increases significantly till after some 24 hours and the peak appears to be shifted, though slightly, toward higher concentrations.

These relations are considered to be advantageous for *Tigriopus* to survive elevations of water temperature in summer months which are liable to be accompanied by concentration of sea water due to evaporation.

6. It is inferred from the above results 1–4 that the acquisition of heat resistance in acclimation to temperatures below 20°, *i.e.* the optimum temperature for the life of *Tigriopus*, is different in mechanism from that in acclimation to

higher temperatures. The latter is certainly caused by temperature acclimatization in the strict sense of the term, while the former should be ascribed to the inactivation of aerobic metabolism by cold, which leaves its effect fairly long after temperature is raised.

Acknowledgements

The writer wishes to express his heartiest thanks to Prof. D. MIYADI of the Kyoto University and Prof. W. OHSAWA of the Osaka City University for valuable criticisms and discussions, to members of the staff of the Seto Marine Biological Laboratory for providing the writer facilities to collect the experimental materials, and to the members of the Adaptive Variation Research Group for encouragements and valuable discussions. He is also indebted to Mr. T. KIMURA for photomicrographic illustrations.

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EXPLANATION OF PLATES XVI–XVII

PLATE XVI

Fig. 1. View of the rocky shore of Sakinoyu, near the Seto Marine Biological Laboratory, where *Tigriopus japonicus* MORI occurs abundantly.

Fig. 2. Near view of the natural habitat of *Tigriopus japonicus* MORI, showing two tide pools on the upper rocky shore, where experimental materials were collected.

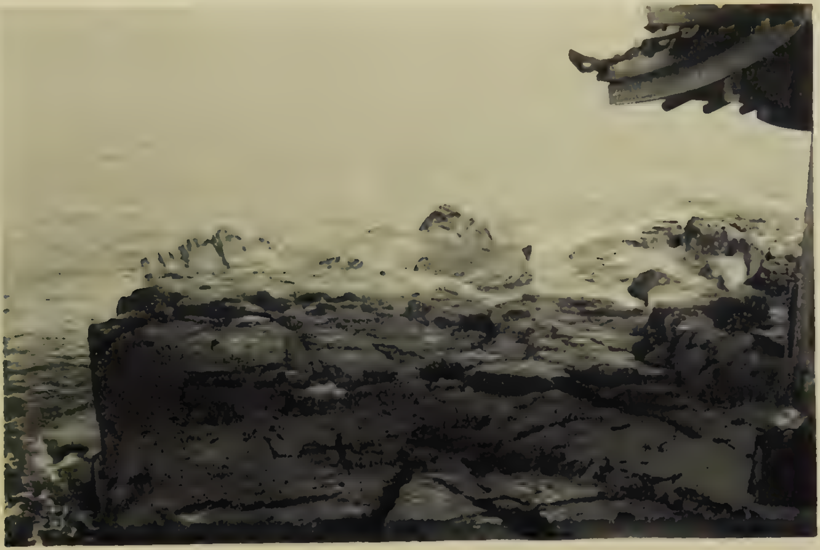
PLATE XVII

Fig. 3. Adult male of *Tigriopus japonicus* MORI.

Fig. 4. Adult female carrying an egg sac.

Fig. 5. Adult male killed by heat.

Fig. 6. Adult female killed by heat.



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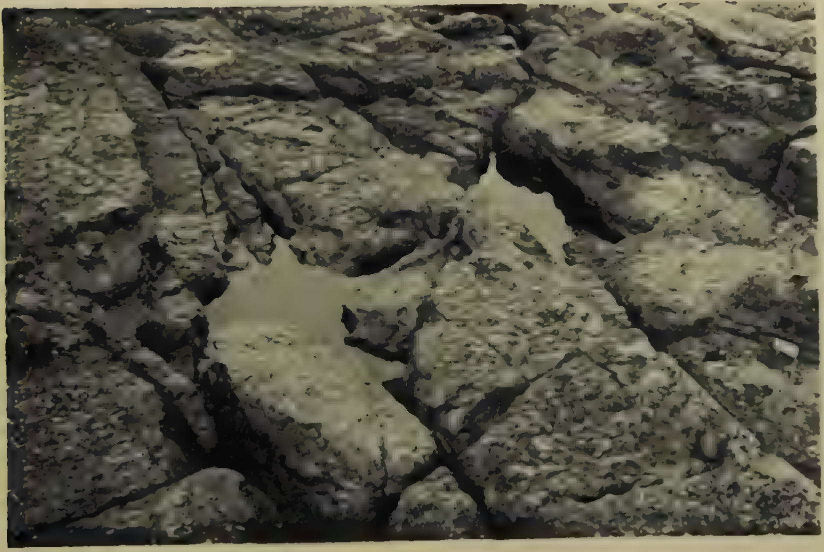

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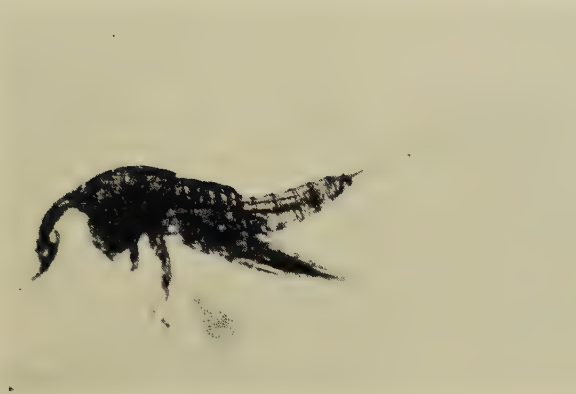
K. MATUTANI: HEAT RESISTANCE OF *TIGRIOPUS JAPONICUS*



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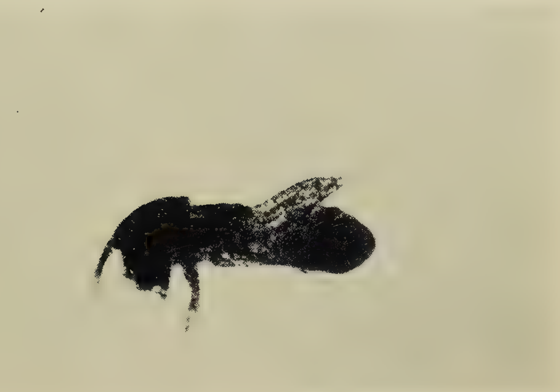

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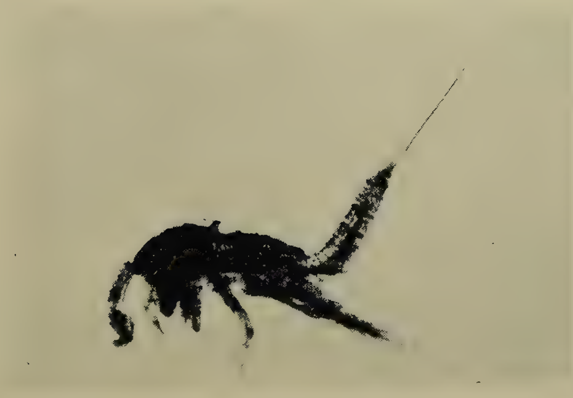

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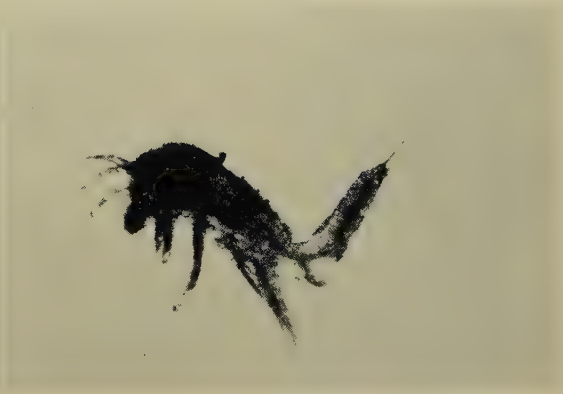

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K. MATUTANI: HEAT RESISTANCE OF *TIGRIOPUS JAPONICUS*

STUDIES ON THE CIRRIPEDIA ACROTHORACICA

III. DEVELOPMENT OF THE FEMALE AND MALE OF *BERNDTIA PURPUREA* UTINOMI[1]

HUZIO UTINOMI

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With 15 Text-figures and 2 Tables

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Introduction

This is a continuation of my "Studies on the Cirripedia Acrothoracica" and represents the last part of the accounts on *Berndtia purpurea* UTINOMI. In the first part of this series the ecology and external morphology of the female were treated (UTINOMI, 1957) and in the second part the internal anatomy of the female was described in detail (UTINOMI, 1960). Here in this third part the larval development of both the female and male, and the morphology of the adult male will be given.

Very little is known of the development of the Acrothoracica, except for that of *Trypetesa lampas* (HANCOCK), which was first described by HANCOCK (1849) and DARWIN (1854) rather briefly and later studied by KÜHNERT (1934) in more details. Although I could not succeed to trace the whole course of development in both the female and male for the Japanese peculiar acrothoracican *Berndtia purpurea* UTINOMI, the following accounts concerning the young stages of the female and male and the detailed structure of the male will contribute to

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[1] Contributions from the Seto Marine Biological Laboratory, No. 376.

Publ. Seto Mar. Biol. Lab., IX (2), 1961. (Article 22)

the embryological study of the Acrothoracica to some extents.

Post-embryonal Development of the Female

According to KÜHNERT (1934), *Trypetesa lampas* is sexually mature and fertilizes during the summer from May to August in Helgoland, and its larvae are, according to VISSCHER (1938), found most abundantly in June but rarely in late July and August in the water around Woods Hole, North America.

In my case, the specimens of *Berndtia purpurea* collected at intervals during the late summer period of August-September were mostly over 5 mm in total length, thus sexually mature in a condition of being more than one year old. Yet individuals containing fully developed ovarian mass and eggs were comparatively few in number, although mature males were sometimes found together with the females (See Table 2, p. 000). The rest of larger ones were found to contain only a medium-sized ovary and a few also with developing ova. A few small individuals, apparently liberated in this summer, were occasionally found on the surface of the coral inhabited by the adult females. Most of them measured about 0.8 to 1 mm in total length. The ova contained in the mantle cavity of the adult females were all in an advanced stage of development just before hatching. No or little individual which contained the developed nauplii freely in the mantle cavity was ever found.

Previous authors state that the metamorphosis of *Trypetesa lampas* from the egg to the metanauplius hastily takes place within the mantle cavity of the parent, and that the free-swimming cypris larva is then removed from the parent. From the condition of the gonad and larvae mentioned above, it seems certain that the fertilization of *Berndtia purpurea* actually takes place and the succeeding development advances very rapidly during the early summer, as in *Trypetesa lampas.*

The early development of the eggs generally agrees with that of *Trypetesa* described by HANCOCK (1849). The number of eggs carried by an individual is generally from 20 to 60, but may be as large as 90 (*cf.* Table 2). This number coincides well with that in the case of *Cryptophialus minutus,* which is according to DARWIN (1854) only 19 to about 60, the number being less numerous than in the deepsea-living Scalpelliform cirripeds and further exceedingly less than in most of the littoral cirripeds.

The development of the fertilized eggs proceeds in the mantle cavity of the parent. The eggs are all connected together by a delicate transparent membrane investing them to form the so-called ovigerous lamella. The developing ova here examined all belong to the last blastula stage or more advanced embryo, so that I have failed to observe the whole course of segmentation. However, in all probability, the segmentation of the ova may advance essentially in the same way as in ordinary cirripeds, as known through the works by GROOM (1894) and BIGELOW (1902) on *Lepas* and by KRÜGER (1922) on *Scalpellum* and by DELSMAN (1917) on *Balanus.*

The youngest stage of segmented ova observed tolerably well is shown in Fig. 1B. They and more advanced ones are ellipsoidal in shape and enveloped by an extremely thin membrane (*e.m*) leaving a slight space between. They measure about 0.26–0.33 mm in longest diameter and about 0.22–0.24 mm in shortest diameter, which size varies little in individuals and not much more than in the unsegmented ova whilst within the oviduct. Usually one pole of the egg membrane is constricted to form a slight attachment-process (*a.pr*) by which the egg connects with the adjoining one.

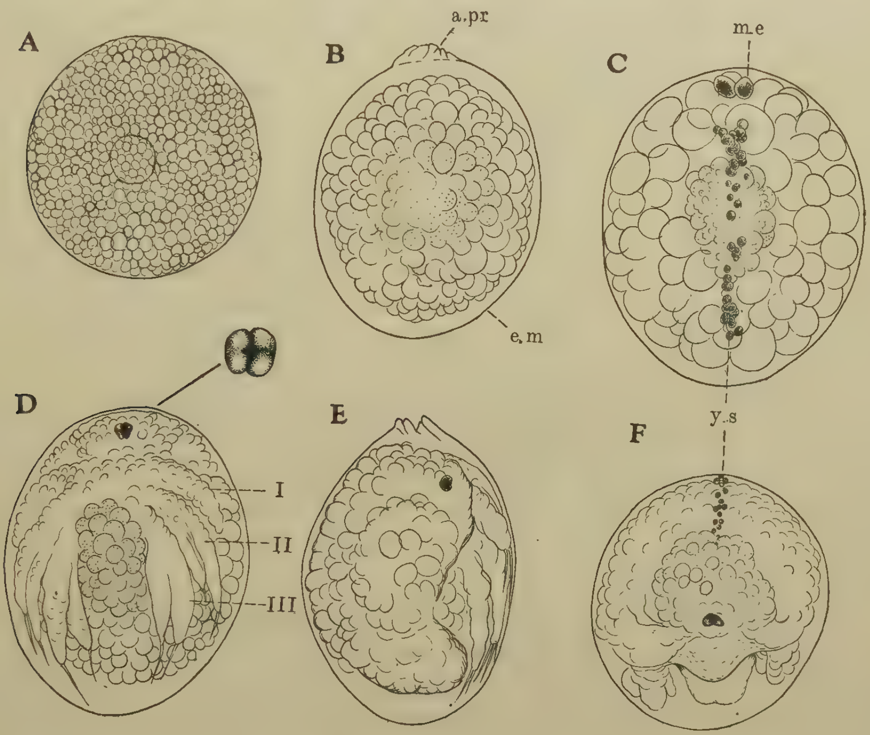

Fig. 1. Post-embryonal development of the female of *Berndtia purpurea* UTINOMI. A, unfertilized ripe egg. B, youngest embryo in egg membrane. C, more advanced embryo showing the median eye appeared in front, dorsal view. D, nauplius-egg with three-paired appendges (I–III), ventral view. E, the same, lateral view. F, the same, frontal view. Lettering as on p. 446. (×120)

The embryo, in which the segmentation has been totally completed, is colored maple orange in its central part and surrounded with the homogeneous spherical cell-masses (blastomeres), being distributed uniformly around it. In the next stage

(Fig. 1C), the central part becomes smaller than before and aggregated to an orange-colored distinct cluster. The remaining part becomes more slightly colored and even transparent. Along the median dorsal line of the longitudinal axis a series of lemon-yellow substances (*y.s*) begins to appear over the surface, but not on the ventral side. Such yellow substances do not appear in the course of segmentation of other ordinary cirripeds, as far as I am aware. In this stage, appears the first rudiment of the median eye (*m.e*), lying at the upper end of the median row of yellow substances, despite that the actual differentiation of limbs does not yet take place. This fact seems to be an important peculiarity in development, common to all members of the Acrothoracica. The formation of a median row of yellow substances, by which the dorso-ventrality of the egg is clearly perceptible, may also be characteristic. The rudiment of the median eye, lying somewhat towards the ventral side, is purplish black and distinctly divided into two symmetrical lobes which are united together in the middle. Its structure differs little from that of the nauplian eye in ordinary cirripeds (FALES, 1928).

As to the succeeding segmentation of the embryo in ordinary cirripeds, earlier authors such as BIGELOW and DELSMAN have arrived at the same conclusion that two segmentation furrows appear first on the dorsal side, instead of ventral, and become deeper rapidly to form the three pairs of appendages, and that as soon as the appendages are formed, their attachment proceeds to the ventral side. However, I could not ascertain the above fact in this acrothoracican. As is shown in the shortly advanced stage (Fig. 1D–F), the dorsal side is still evenly much convex as in the preceding stage without any indication of transverse furrows, while the ventral side is very concave in the middle there, appearing the three pairs of appendages. Similar feature has already been observed by HANCOCK (1849) in *Trpyetesa lampas.*

In this stage, which may be called the egg-nauplius, the embryo is about as large as that in any of the preceding stages. Now the posterior end becomes somewhat protruded and slightly incurved. The anterior end is evenly rounded and the rudiment of the fronto-lateral horns is scarcely defined. The median eye is bilobed, with a distinct median incision; each lobe is more elongate than before and often marked with a slight transverse constriction dividing into two parts each of which represents a visual cell. On the ventral side appear the three pairs of appendages; of these the first one is still simple, while the remaining two are biramous and each ramus is provided with a short bristle at the end.

As development still goes on, the segmentation of the appendages becomes distinct and the number of bristles on the appendages increases. The peculiar yellow substances on the dorsal side disappear, probably as decomposed with yolk substance. The fronto-lateral horns become more distinct and on each side below the median eye soon appears a frontal filament. The posterior end of the body becomes more pointed and greatly elongates to develop into the thoraco-abdominal process, though still incurved. Still the dorsal side of the body is strongly arched. Through such change, the embryo comes to present the typical features all characteristic to the nauplius larva of the Cirripedia. Now it measures about 0.32 mm in length as well as breadth, excepting the terminal process (Fig. 2A, B).

The larva of such a stage has already undergone its full development in the egg and is ready to hatch out. Such a larva is observed in stretching movements within the egg-membrane and in pressing the arched back against the membrane as if it attempts to free itself. Eventually, the membrane ruptures at its antero-dorsal region, whence emerges the larva into the exterior.

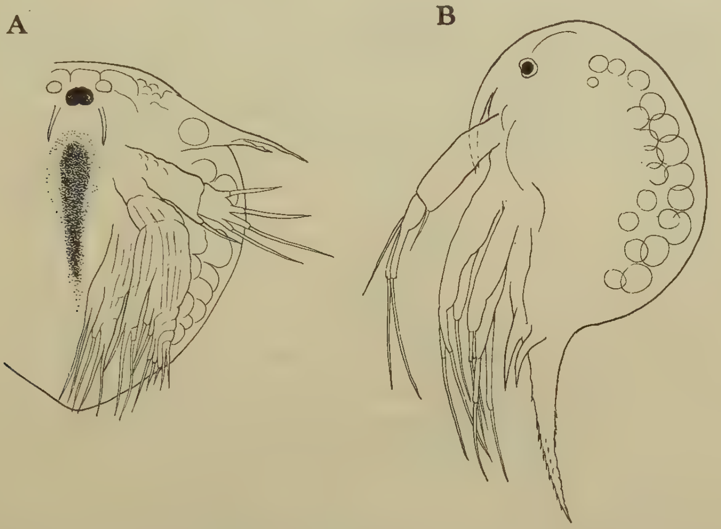

Fig. 2. Nauplius larva immediately before hatching in ventral view (A) and in lateral view (B). 〔×140〕

Older Nauplii

The hatched larva is the same as that of *Trypetesa lampas*. Such a nauplius (Fig. 3A) measures 0.47 mm in length from the anterior end to the end of the ventral thoraco-abdominal process, and 0.26 mm in width across the dorsal shield immediately posterior to the fronto-lateral horns. The size here given corresponds to that of *Trypetesa lampas* (0.45 mm long after KÜHNERT), and is apparently about twice as large as that of the corresponding stage of ordinary cirripeds; for example, 0.22 mm long and 0.12 mm wide in *Balanus crenatus* (HERZ, 1933), and 0.24 mm long and 0.14 mm wide in *B. amphitrite albicostatus* (ISIDA & YASUGI, 1937). This interesting fact that the large-sized eggs in small number are contained in the female, is probably due to the reduction of metamorphosis resulted from its semiparasitic or hypobiotic habit.

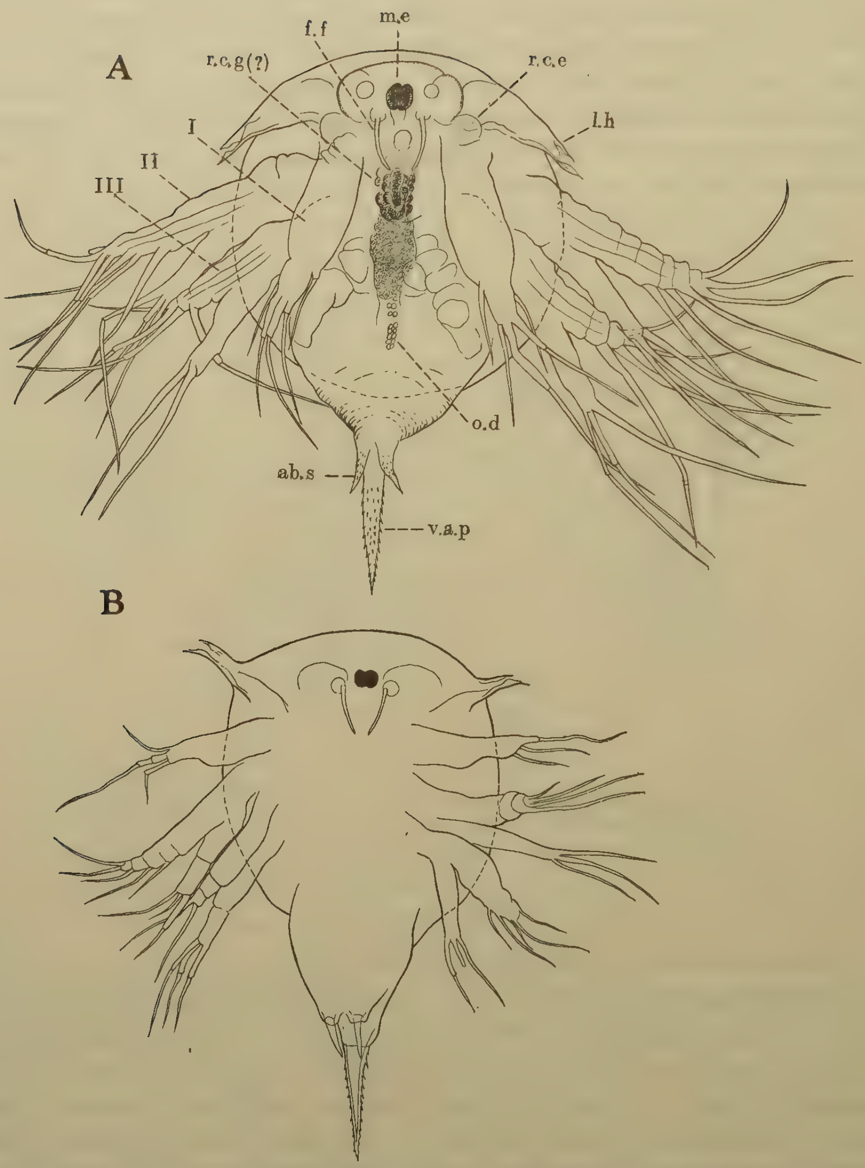
A
m.e
f.f
r.c.g(?)
r.c.e
I
II
III
l.h
o.d
ab.s
v.a.p
B

Fig. 3. A, nauplius larva just hatched out, in ventral view. I–III, first to third naupliar swimming appendages. B, nauplius larva after first moult. Lettering as on p. 446. [A ×140; B ×120]

The dorsal shield of the body is ovoid in outline, broad in width, and its posterior end is evenly rounded without any spine; thus it is more plump than that of ordinary cirripeds. The ventral thoraco-abdominal process (*v.a.p*), measuring about 0.14–0.17 mm in length, is sharply pointed at its end, instead of being forked. From its base a pair of short abdominal spines or 'Seitenstacheln' (*ab.s*) are produced backwards. Both the process and spines are wholly covered with minute spinules. The fronto-lateral horn (*l.h*) is directed posteriorly and opened at its end. The median eye (*m.e*) is formed of two symmetrical ovoid lobes fused together. Immediately posterior to the eye a pair of the frontal filaments (*f.f*) are situated, as is the case with *Trypetesa*—its situation to the eye seems to be characteristic to the nauplii of all acrothoracicans. On each side of the eye there is a large, round and vacuolated structure of empty content. The brain attached posterior to the eye is not clearly distinguishable from the outside, but the rudiment of the cypris eyes (*r.c.e*) can be seen at the base of the first swimming appendage. The central part of the mid-line of the body is nearly opaque and mounded with purplish-brown visceral mass (*r.c.g*) under the surface, which may answer to KÜHNERT's 'Klebdrüse' in *Trypetesa.* No labrum is formed there. The rest of the interior of the body is filled with large yolk-spherules of orange color, as can be easily differentiated from the connective tissue.

All three pairs of appendages, which are homologically the antennule, antenna and mandible respectively, are slightly articulated and bear long bristles at the tip and inside of the terminal portion. The so-called 'Enditen', namely bristles at the pedicel, which usually occur in the nauplii of sessile cirripeds, are wanting. More interesting is the fact that the bristles on the appendages are mostly, though not at all, formed of two joints, the distal joint being deeply intruded at its base into the basal joint. This peculiar feature is shared also by the nauplii of *Trypetesa lampas*, as has been noticed by HOEK (1909) and NILSSON-CANTELL (1921). Probably this is also an important characteristic of the nauplii of the Acrothoracica in common.

The next stage after the first moult is slightly larger than the first stage (Fig. 3B). It measures about 0.57 mm in length and 0.27 mm in width. The thoracic portion, bearing the ventral abdominal process at the tip, has greatly elongated beyond the dorsal shield, and the spinules on the process become sparse; yet the rudiment of ordinary thoracic appendages does not appear on the ventral side of the thorax. The swimming appendages show no new structures, but the terminal bristles begin to degenerate, as described by KÜHNERT in *Trypetesa.* In all other cirripeds as well as in most of other crustaceans, the bristles on the appendages usually increase their number and size rather regularly with every moult, while the present case (probably other acrothoracicans also) is quite opposed to the above. This fact suggests that the nauplius stage passes on very rapidly in the whole course of metamorphosis and does not moult so many times

Table 1. The number and length of bristles on the appendages in the nauplius stage.

Number of bristles	Unhatched nauplius	1st nauplius after hatching	2nd nauplius after 1st moult
1st appendage	5	5	3
Exopodite of 2nd appendage	7	6	5–4
Exopodite of 3rd appendage	4–3	4	4–2
Length of terminal bristle on exopodite of 2nd appendage	0.08 mm	0.19 mm	0.10 mm

as does that of ordinary cirripeds (See Table 1).

The succeeding stages of metamorphosis up to the cypris could not be followed out. According to Kühnert (1934), the larva of *Trypetesa lampas* developes to the cypris passing through three nauplius stages and one metanauplius stage in about a week, though Visscher (1938) states that it passes through six nauplius stages or moults, as is the case with most littoral cirripeds. Although little data are available, I am rather inclined to support the former view from the above-mentioned fact. However, it is out of the question in the present case whether or not it truly passes through the metanauplius stage as does *Trypetesa.* As to this problem one will be referred to the statement on the development of the male given later.

Post-larval Development and Disc-formation in the Female

The young larva of the female which has finished the metamorphosis is about 1 mm in length and 0.4 mm in width, as far as I observed. Its general feature differs in no respect from that of the adult female, except that the orifice on the rostral side lies parallel to or a little obliquely to the longitudinal axis of the animal, instead of being at right angles to the latter.

Such a larva is lodged, without exceptions, on the soft tissue of living corals lying on the crevice between the septa of calices, the rostral side with a slit-like orifice facing upwards and the carinal side downwards. The uppermost end, which agrees with the carinal end of the orifice is invariably directed toward the margin of the calice and the opposite end is deeply concealed in the soft tissue toward the central mouth, so that the animal lies obliquely to the surface of the coral. Accordingly, the rostral face below the orifice, which will develop into the attachment-disc in future, is partially exposed outsides in the early stage. However its lower end does not reach the calcareous skeleton of the coral as yet (Fig. 4). From such mode of attachment it may be assumed that the young larva first settles on the soft tissue of the coral obliquely to the surface, and then continues to grow in circumferences, before actually excavating by its own power.

At the beginning of excavation, the larva adheres, as usual in all the others, to the surface of the soft tissue of the coral with the antennules at its anterior end. As regards the position of attachment of the antennules in the young of *Trypetesa*, opinions of earlier authors are diversified. DARWIN (1854) first considers that the antennules are attached to the anterior or lower end of the mantle ('peduncle' as he calls), while BERNDT (1903a) and GENTHE (1905) maintain that they are attached near the lower end of the orifice where the body connects with the mantle. A recent study on the development made by KÜHNERT (1934) substantiates that the former view is more accurate. The same view can be applied to the present case. Namely, as clearly shown in Fig. 4, the rostral side of the mantle below the orifice is quite free from the area of attachment in the larval stage. Although I have not seen such an early stage still bearing the antennules, it may be admitted that when the young female is once attached, its anterior or lower end grows to extend upwards and the antennules attached there soon become wholly degenerated.

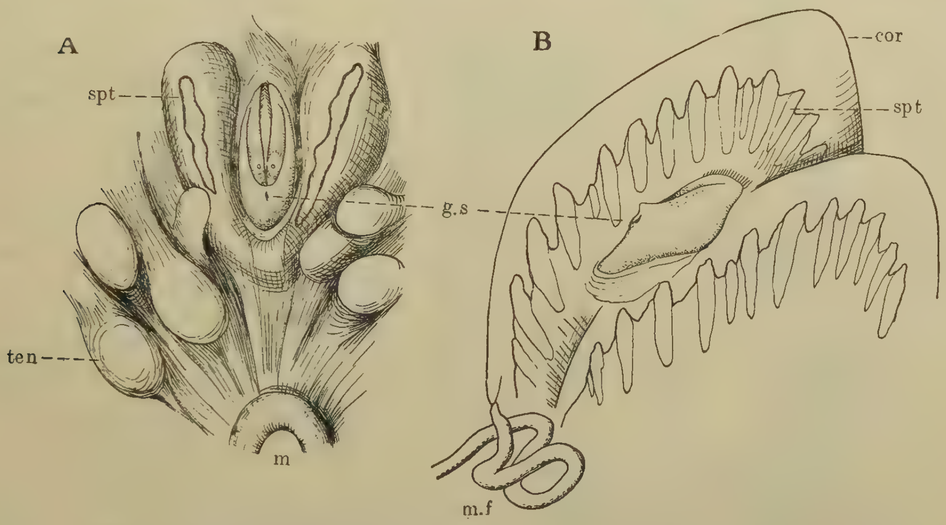

Fig. 4. Initial posture of young *Berndtia* lodged on the soft tissue of the coral *Leptastrea purpurea*, in upper view (A) and in lateral view (B). Lettering as on p. 446.

Around the lower end of the animal which is wholly embedded within the soft tissue of the coral, a thin calcareous layer is sometimes seen. This outer coat (Fig. 5A–C, *c.l*) is made up of fragile and irregular patches of calcareous matter, but not cemented to the surface of the animal. Undoubtedly this is by no means the product from the animal proper, but that from the host coral, as the secretion and deposition of calcareous substance may be induced owing to the occurrence of this intruder. With the accumulation of calcareous substance according to the gradual upward growth of the host coral, leaving alone the surrounding part of the orifice. As the upward extension of the calice of the coral and the growth of the animal in all directions proceed on, the lower end of the animal becomes to adhere to the calcareous skeleton of the coral. Further, the cavity thus formed around the animal in the coral becomes deeper and larger by its own power of excavation.

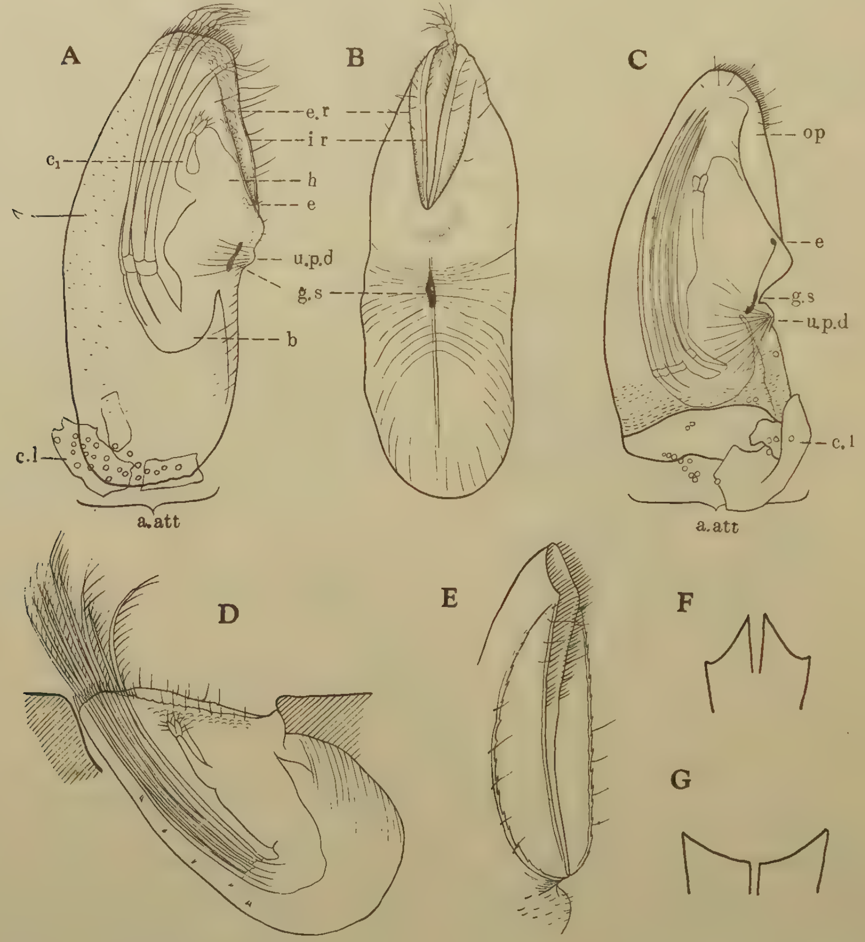

Fig. 5. Young stages of the female. A, lateral view of a specimen. B, rostral view of the same. C, lateral view of another specimen. D, a more advanced stage commenced boring action. E, frontal view of operculum in the initial stage. F, diagrammatic figure showing the section of operculum in larval stage. G, the same in adult stage. Lettering as on p. 446. 〔A–C ×60 ; D ×55 ; E ×80〕

As growth goes on, the area of attachment around the antennules at the lower end of the animal becomes wider and longer to form the so-called disc. The external membrane over the whole surface is periodically and often moulted, but that over the disc alone is forced to be left unmoulted owing to its adhesion to the wall of the cavity and thus becomes thicker than elsewhere, as I have noticed before (*cf.* UTINOMI, 1957, pp. 11–12; UTINOMI, 1960, pp. 257–258).

The animal is at first attached to the supporting surface almost obliquely, but later takes its position almost vertically by lengthening upward the supporting surface, as the upward growth of the coral becomes pronounced. Consequently, the disc, which was at first almost round to oval in outline, becomes narrower and more elongate like a spoon, by adding periodically the newly formed or thickened membrane above the old membranes along the rostral side at each exuviation. This is clear from the fact that the disc, when seen from inside, is formed of succesive laminae of cuticular structure extending beyond each other, which are defined by growth-ridges scarred on the surface, and that the laminae become distinct towards the upper end where the new zone of growth is formed; the lower rounded part of the disc, which answers to the initial position of attachment, presents no trace of lengthwise accumulation of the chitinous lammellae. A series of growth-ridges may thus record the number of times of moult (Fig. 6). Such a mode of formation reminds one much of the formation of the sublateral style as well as the attachment-disc in the rock-boring cirriped *Lithotrya* (CANNON, 1935); in the latter case, however, the new zones of calcareous laminae and cuticular coverings are, on the contrary, added on the lower margin of the

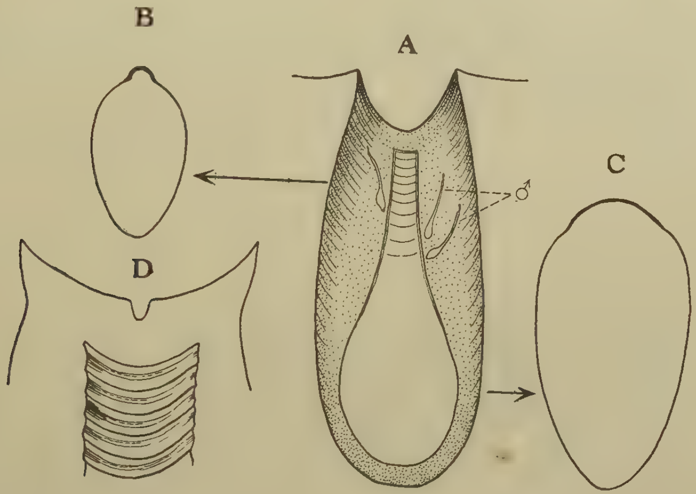

Fig. 6. A, diagrammatic figure of a longitudinal section of burrow of *Berndtia* showing the lodgement of males (♂) and the outline of attachment-disc. B, section on upper level. C, section on lower level. D. upper portion of burrow showing the cuticular laminae of disc, highly magnified.

plates, as the capitular plates as well as the peduncle grow downwards at each ecdysis.

Anyhow, the formation and enlargement of the burrow is actually correlated with the growth of the host coral, so that the deepening of the burrow in this case is comparatively little appreciable. In this respect, the mode of excavation is not the same as that shown in other acrothoracicans like *Trypetesa lampas*, and also in *Lithotrya* of ordinary cirripeds. Such disparity may be due to that the latter two bore into any lifeless thing of calcareous matter, but not into living thing. As a matter of fact, the amount of excavation is more pronounced in *Trypetesa* as well as *Lithotrya* than in *Berndtia*, because of the remarkable downward, instead of upward, extension of the attachment-disc.

As the coral grows upwards, the animal imbedded within it lengthens the lower part, then the area of attachment, becomes lengthened up to the slight swelling below the orifice. Finally the animal becomes firmly cemented to the calcareous skeleton of the coral at the area of attachment in accordance with the growth of corallites. At this time the actual course of excavation first commences. The excavation is clearly mechanical, being performed by means of the chitinous spines all over the surface which were described already in detail (*cf.* UTINOMI, 1957, pp. 10–11 and fig. 5). At each excavation or contraction of the mantle, the lateral bar lying alongside the upper part of the disc may serve as fulcrum by pressing against the side wall of the burrow. This may be inferred from the fact that deposits of fine calcareous granules which may have been triturated at each excavation can be seen along the outer margin of the bar. The orifice of the burrow is usually surrounded by similar deposits of coaser granules. Such a structure is not yet formed in any early stage, before the external membrane of the mantle becomes thicker to form the cuticular coverings.—In short, the young *Berndtia* first cannot bore itself into the coral skeleton till the mantle becomes wholly surrounded by the soft tissue of the coral and then by the calcareous skeleton. In other words, after the formation of its own cavity and attachment-disc, the excavation actually takes place.

Next, I may mention the remarkable change in the remaining structures during the course of development. As stated above, the orifice in the initial stage lies in a line with the rostral surface of the mantle below the orifice, and evenly arched. The lower end of the orifice is now slightly produced. The orifice is bordered by the outer slight ridges, leaving a broad flat interspace between. The outer ridge, which arises from the lowest swelling of the orifice and blindly ends upwards, is much lower than the inner ridge forming the entire edge of the orifice; in the adult, however, it becomes more sharp and higher than the inner edge, forming the outer edge of the operculum (Fig. 5F, G). The outside of the orifice is adorned with long hairs rather sparsely all along, while the inside is furnished with a row of shorter hairs towards the upper half.

This inner row of hairs is the future comb-collar (Fig. 5A–E).

A little below the lower protruded end of the orifice, there is formed a slight swelling (*u.p.d*) under which an elongate black body (*g.s*) is situated. At first sight this black body appears to be a vestige of the nauplian eye, but judging from its position it may be the rudiment of the cerebral or supra-oesophageal ganglion, which is still unpaired as shown now. The true eye, which has been differentiated from the cerebral ganglion, may be seen at the same position as mentioned in the adult, though still very obscure in early stages (*cf.* UTINOMI, 1957, p. 7, fig. 2; UTINOMI, 1960, pp. 250–253). The other ganglia which are prominent in the adult are not discernible as yet.

The internal body within the sac is almost the same as in the adult, though still much smaller. The muscles of the mantle are not well developed, only with indications of radial or oblique muscle fibres running from the slight swelling below the orifice in a fan-like manner. No trace of the longitudinal muscles is discernible. This may offer another evidence for the inability of excavation by its own power still now.

Life-habit of the Male

The dwarf male of *Berndtia purpurea* can easily be obtained by searching carefully among the slit-like burrows of the female. The males are generally attached alongside the upper narrow portion of the attachment-disc of the female adhering to the wall of the burrow. They adhere by means of the terminal segment of their antennules at the anterior end to the wall of the burrow, and exclusively stand upright, extending upwards their greatly prolonged posterior portion (Fig. 6A). In some cases, however, they are exceptionally attached to the female body, lying alongside the disc. Thus, the manner of occurrence of the males in this species is quite unique among the group, for in other acrothoracicans the males are generally attached to the female body.

In each burrow of the females, 1 to 6 males are found. I have sometimes seen more than one male on the left side, but fewer or none on the right side. However, this is probably merely accidental. In this connection I examined a number of females to detect a certain relationship between the impregnation of the ova in the female and the occurrence of the males in the same burrow. Materials for this purpose are all those embedded in *Leptastrea purpurea* collected in the middle of August, 1942. A series of specimens were chosen, covering the full range of sizes of the female, and the size of each female together with the number of the males which were found together within the same burrow, were measured, and then the mass of fertilized ova contained in the mantle cavity of the female was counted. The results obtained are given in Table 2.

Table 2. Relation between the number of males and the size and development of the females.

Length of operculum of females (mm)	Number of males	Number of ripe eggs or nauplii	Condition of female gonads
1.2	1	—	—
1.7	0	—	—
1.7	1	—	—
1.7	1	14	—
1.8	0	—	—
1.8	1	—	—
1.8	1	—	—
1.8	2	+	not ripe
1.9	1	—	—
2.0	0	—	—
2.0	2	—	—
2.1	0	—	—
2.1	1	—	—
2.1	2	—	very ripe
2.2	1	—	—
2.2	1	—	—
2.2	2	—	ripe
2.2	1	65	—
2.3	0	—	—
2.3	1	—	—
2.3	2	—	—
2.3	4	—	—
2.4	1	—	—
2.4	2	—	—
2.4	2	—	—
2.4	3	—	—
2.4	3	21	—
2.5	2	—	—
2.5	1	85	—
2.6	1	—	—
2.6	3	—	ripe
2.6	3	—	very ripe
2.6	1	64	—
2.6	2	57	—
2.7	1	—	—
2.7	1	—	—
2.7	2	—	—
2.7	1	—	very ripe
2.7	1	+	not ripe
2.7	3	—	very ripe
2.7	5	+	—
2.7	5	32	—
2.8	1	—	very ripe
2.8	2	—	—
2.8	3	—	very ripe
2.8	4	—	—
3.3	6	—	very ripe

+ present, but not counted. — absent, or not examined.

From this results, however, I could not detect any positive evidence proving cross fertilization in the same cavity, since the majority of the females are always found associated with one or more males, and some of them contain a mass of ripe ova or nauplii but none the rest. No female individual, which is not associated with the male, containing the developing ova in the mantle cavity is ever found. The number of males found to live together with one female is more in older females than in younger ones. The frequency of occurrence of sexes is on an average 1.8 : 1 between the male and female. This ratio is somewhat smaller than that in *Trypetesa lampas* (about 2.4 : 1 after Kühnert). This fact is very interesting when compared with the case of deepsea-living Scalpellid cirripeds having dwarf males, in which the male is much less in number than the female.

Concerning this problem, Darwin (1854) states for *Trypetesa* that "It is obvious that these males must be very short-lived: they perform their masculine functions and then perish. We have seen, however, that after the act of metamorphosis they do grow a little, and I have reason to suspect that this is effected, as with other cirripedes, by moulting." and further says that "The females must breed more than once during their lives; and therefore successive sets of males, as in the genus *Scalpellum*, must become attached to them."

Apparently the case of *Berndtia purpurea* is also the same as the above, but as mentioned above the male is never effected by moulting of the female, because it usually does not adhere to the female. However, I met with only once the remains of an old male firmly attached by the antennules to the wall, being devoid of any internal body content. Indeed, judging from the degenerated structure of the internal organs excepting the generative organ, it is likely that the act of masculine function is a main or only object of life for himself. And from their protected habit it may be assumed that the males can survive only in association with the female, and that the ordinary cross fertilization between sexes within the same burrow may be possible.

Post-larval Development of the Male

According to Kühnert (1934), the cypris larva of *Trypetesa lampas* cannot be phaenotypically determined into sexes, both anatomically and histologically, until settling on any substratum takes place. Such cypris larvae as can be identified as the pure male are sometimes found attached to the wall of the burrow in which the adult female is lodged. After searching on many materials I happened to find some spats of the male newly settled, but unfortunately failed to find any younger staged larva. Nevertheless, the following observation on a series of these larvae presents not only some new and interesting facts regarding the metamorphosis peculiar to this form but also provides a problem about the sexual dimorphism of the group.

Before describing the metamorphosis, we must take into account the peculiarities of the metamorphosis in the other known acrothoracicans. One of this group, *Cryptophialus minutus* alone shows a very unique manner of metamorphosis, as studied by Darwin (1854), for it does not pass through the ordinary nauplius stage, but develops into the pupa bearing no thoracic appendages within the sac of the parent. In *Trypetesa lampas*, on the other hand, the larval development is performed by passing through three ordinary stages, such as nauplius, metanauplius and cypris, as usual in other cirripeds, although it proceeds on more hastily ; in the nauplius stage, three pairs of swimming appendages are present and in the later stages six pairs of thoracic appendages also can be seen in both sexes, as in ordinary cirripeds (Kühnert, 1934). In this way, the larval development of *Berndtia purpurea*, at least in the male, is more like that of the former *Cryptophialus* than the latter *Trypetesa*, and probably represents about an intermediate state between them.

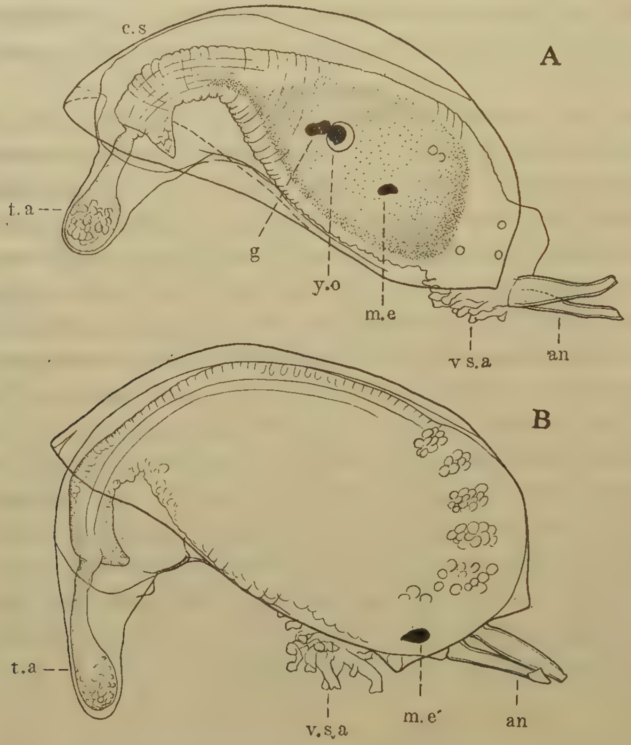

Fig. 7. Pupal-staged larvae of the male (A, B). Lettering as on p. 446. [×120]

All the larval specimens I have examined are of the oldest pupal stage, showing nearly the characters of the adult male. As is shown in Figs. 7 and 8, the general feature of these pupae exhibits definitely several peculiarities in comparison with the same-staged males of *Trypetesa.* In a somewhat younger form measuring about 0.5 mm in shell-length and 0.23 mm in breadth, the main part of the body is completely enclosed within the bivalve shell (cypris-sac) which has developed from the dorsal shield of the nauplius larva. The cypris-sac (*c. s*) is almost the same as that of any other cypris larva, except only that its anterior end is somewhat pointed.

The body under the shell is flask-shaped, though not so elongated as in the adult male, and encircled all over with numerous transverse wrinkles and completely enclosed within the closed mantle-sac in a constricted state. At the anterior end of the ventral surface, a pair of simple rod-like antennules are protruded anteriorly: it consists of apparently one or two segments, as in the adult. On the ventral surface near the antennules there remains an entangled mass of chitin exuviae (*v. s. a*); from its position they may be referable to the vesitiges of the second and third swimming appendages (antennae and mandibles) appeared in the nauplius stage. This fact is of great interest and presents a striking contrast with the fact that in other cirripeds such naupliar appendages are always reduced to shapeless vestiges in the metanauplius stage and then completely thrown off before passing into the cypris stage. Indeed, the cypris larva of *Trypetesa* has the thoracic appendages still remained but not the naupliar swimming appendages. In the present larva, however, the thoracic appendages are quite lacking, as is the case with *Cryptophialus.*

In ordinary case, the thoracic appendages appearing on the posterior thoracic region at the metanauplius stages are contained within the mantle cavity which is open to the exterior through the mantle opening as in the adult. In the present form, however, the body contained under the cypris-sac is completely enclosed within the mantle sac, which is composed of a continuous thin transparent membrane without any opening. This membrane is possibly the remnant of the body wall at the nauplius stage, since the body proper becomes once reduced in size to form the construction of the adult stage by moulting. Attached to the posterior end of the body, there is a remarkable terminal ampulla (*t. a*) which is already well developed as large as in the adult; it measures about 0.14 mm long and 0.05 mm wide. It is much protruded by far beyond the ventral margin of the cypris-sac, but still wholly enclosed by the membrane of the body mentioned above. The terminal end of the body at the base of this ampulla is produced ventrally into a triangular lobe, which is more marked than in the adult stage. If the ordinary metanauplius stage like that of *Trypetesa* precedes this cypris stage, the vestiges of thoracic appendages should still remain within the closed mantle-sac. Yet there remains no vestige within it, despite that the naupliar appendages still remain on the anterior portion, as mentioned above. This fact may lead us to a supposition that the present form does not pass through the ordinary metanauplius stage in its developmental cycle.

The internal structure of the body is not clearly differentiated as yet, because it is filled compactly with the opaque, pulpy granular matter. But three peculiar black spots can be easily defined. Of these the posterior two are always closely attached; of which the anterior one is larger, rounded in outline and colored more lightly than the posterior one. These two spots are undoubtedly the yellow body and main nerve ganglion respectively, as will be stated below for the adult. The remaining one, which is widely separated from the above two, is wholly black and oval to irregularly round in outline; this is probably the vestige of the median eye in the naupius stage (*m.e′*). Such a black spot is never met with in the adult male. Moreover there is no direct communication between the nauplius-eye and the main nerve ganglion. In regard to the male pupa of *Trypetesa*, Kühnert (1934) states that "Bauchmark und Gehirn mit aufsitzendem Nauplius-Auge wachsen aufeinander zu, um dann zu dem definitiven und einzigen Ganglion des jungen Mänchens zu verschmelzen. Das unpaare Nauplius-Auge bleibt erhalten." I could not distinguish any cypris-eye still remained owing to the opaqueness of the interior, but its presence is certain, as will be stated below.

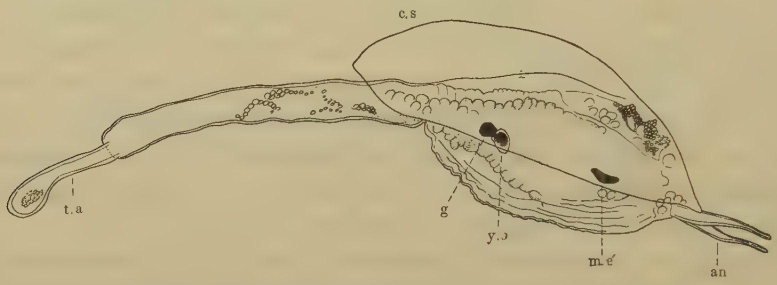

Fig. 8. Young stage of the male with a cypris-sac wholly remained. Lettering as on p. 446. [×90]

In a still more advanced stage (Fig. 8), the cypris-sac still perfectly remains but the vestiges of naupliar swimming appendages are entirely lost. The nauplius-eye, beside the main nerve ganglion and yellow body, is also still present. However, the remaining internal organs such as the genital organ are not yet developed. The body is more elongated as the prolongation of the posterior portion proceeds; the whole length of the body, not including the terminal ampulla, is about 0.88 mm, that is, nearly the same as in the adult, and the posterior prolongation is about 0.47 mm, being longer than the anterior thoracic region.

The mantle-sac, in which the body is enclosed at the younger stage, is reduced to shapeless vestige closely beneath the cypris-sac (*c.s*) which is ready to cast off. The ventral surface of the body is longitudinally striated or rugged. Both the antennules and terminal amplla are almost the same as in the adult.

Morphology of the Adult Male

External Appearance. The adult male (Figs. 9–12), as compared with that of the other acrothoracicans, is very unique in shape, although it resembles in many respects of the internal characters. The body when fully developed is much elongated and tadpole-shaped; its anterior portion which carries a pair of antennules at the rounded end is broad and gradually tapers towards the probosciformed posterior prolongation. At the posterior end there is a peculiar ampulla-like sac (*t.a*). Cross section through every portion shows a round shape. The whole length of the body is about 1.2–1.5 mm, while the width is about 0.2 mm in the anterior portion and about 0.05–0.06 mm in the posterior prolongation.

The anterior main portion of the body corresponds to the 'peduncle' of *Trypetesa* and the posterior prolongation to the 'capitulum' both of which are called by Darwin and Berndt. However, the application of such division of the body as used in the pedunculate cirripeds is inadequate, since there is no distinct demarcation between the anterior and posterior portions; the external resemblance in the case of *Trypetesa* is merely analogical.

Cypris-sac and Antennules. In most cases, the anterior portion of the body is coated with the remnant of the cypris-sac, which is the dorsal shield of cypris-larva (*c.s′*), and adheres to the wall of the burrow by means of a pair of antennules (*an*) at its extremity lying near the ventral corner. In other acrothoracicans, the cypris-sac of the male is known to have been cast off at the last moult of metamorphosis, as in the female. In *Berndtia purpurea*, however, I have not ever found such a nude male even in fully developed stages, a part of the cypris-sac remaining in contact with the anterior end around the antennules. Judging from this fact, it seems probable that the male, when once attached, does not further moult after the final metamorphosis and hence it must be short-lived. The remnant of the cypris-sac is mostly the anterior one-third of the whole, cut off somewhat obliquely just behind the cypris-eye. The sac is smooth, transparent and chitinous all over.

Inside the cypris-sac near the cutting edge I have often found the remains of compound eyes (*c.e′*) of the cypris stage, which are not attached directly to the body proper. In one specimen examined, the remains of the compound eyes appear as consisting of nine or ten transparent globules or lenses surrounded by faintly colored granules. These globules are probably the remains of corneagen cells. Pigment bodies are completely lost. Therefore it is obvious that the compound eyes are cast off with the cypris-sac at the final course of metamorphosis of the cypris into the adult.

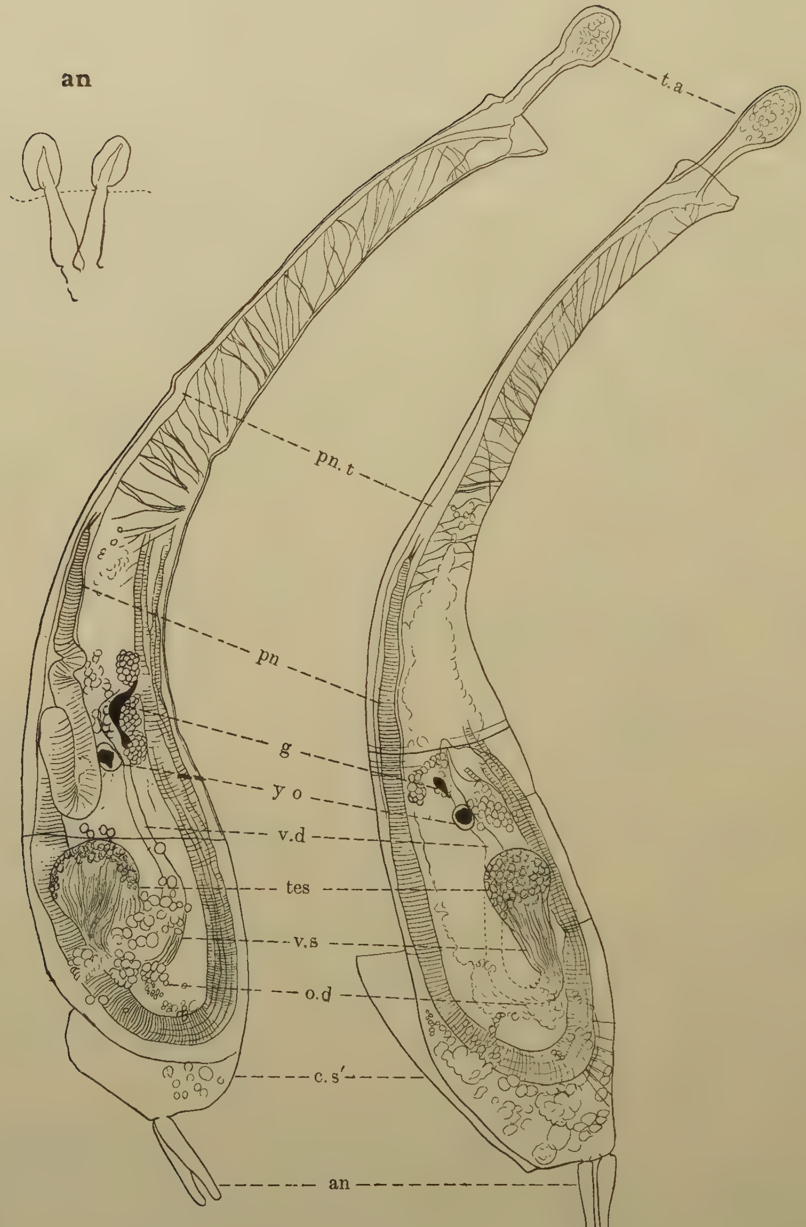
an
t.a
pn.t
pn
g
y o
v.d
tes
v.s
o.d
c.s'
an

Fig. 9. The adult males with the antennules (*an*). Lettering as on p. 446. [×120]

The antennules (*an*), still remained in all cases, are simple, apparently consisting of a rod-like proximal segment, about 0.1 0.14 mm long. The triangular terminal segment, which I once observed, is surrounded by a transparent yellowish mass which may be considered as the product of cement or adhesive gland ('Klebdrüse'). By this terminal segment only the male is attached to the wall of the burrow. But as the wall is sticky owing to the mucous secretion of the coral tissue, the male cannot be easily detached from the wall.

Body wall and its Muscles. The whole external membrane of the body is a chitinous cuticle which is comparatively thin and transparent; hence the internal organs, even the spermatozoa, can be seen from the outsides. Cross section shows that no epithelial cell layer is formed immediately beneath the cuticle. The external surface is clothed with minute thorns (*th*) arranged in transverse intermittent rows, as in the males of *Scalpellum*-species; sometimes these thorns are massed together transversely, not quite so regularly in one row as shown in Fig. 10, and only separated from one another by many transverse folds, of which one or two are particularly distinct and completely surround the body. As a rule, these thorns are all directed posteriorly. They are evidently homologous with the chitinous spines on the mantle of the female described before. According to STEWART (1910), the sensory hairs on the males of *Scalpellum*, which are the same as these thorns, are the specialized outgrowths of the external cuticle and presumably act as the sensory organ, being supplied with peripheral nerves and sensitive to vibration of the water. But I could not detect any trace of nerve in this form.

Just beneath the external cuticle, a layer of very powerful longitudinal muscles (*l.m*) is present. But they are confined to about the middle part of the body, not extending far towards both the anterior and posterior extremities; most of them are about one-third of the whole length of the body. These muscles are bilaterally arranged, one along the dorsal surface and the other on the ventral, leaving a space on the lateral sides between them; both the ends of each muscle are somewhat expanded and attached to the external cuticle. The number of muscles is variable according to the size of the body, but in full-grown specimens about 16 on the ventral side and 19 on the dorsal side. The length is also variable, but generally they become longer and stronger towards the dorsal and ventral sides. All these muscles are, to my surprise, devoid of any trace of transverse striae; in *Cryptophialus minutus*, however, the longitudinal muscles are, according to BERNDT, distinctly striated. As a matter of fact, the body is always fully stretched and can be little contractile; hence I do not suspect that these muscles are of a ligamentous construction, giving support to the whole body. No transverse muscle or fibre is found at all. The posterior prolongation of the body lacks the muscles of any kind, though it is very elastic; possibly it is not contractile too (Figs. 10 and 12).

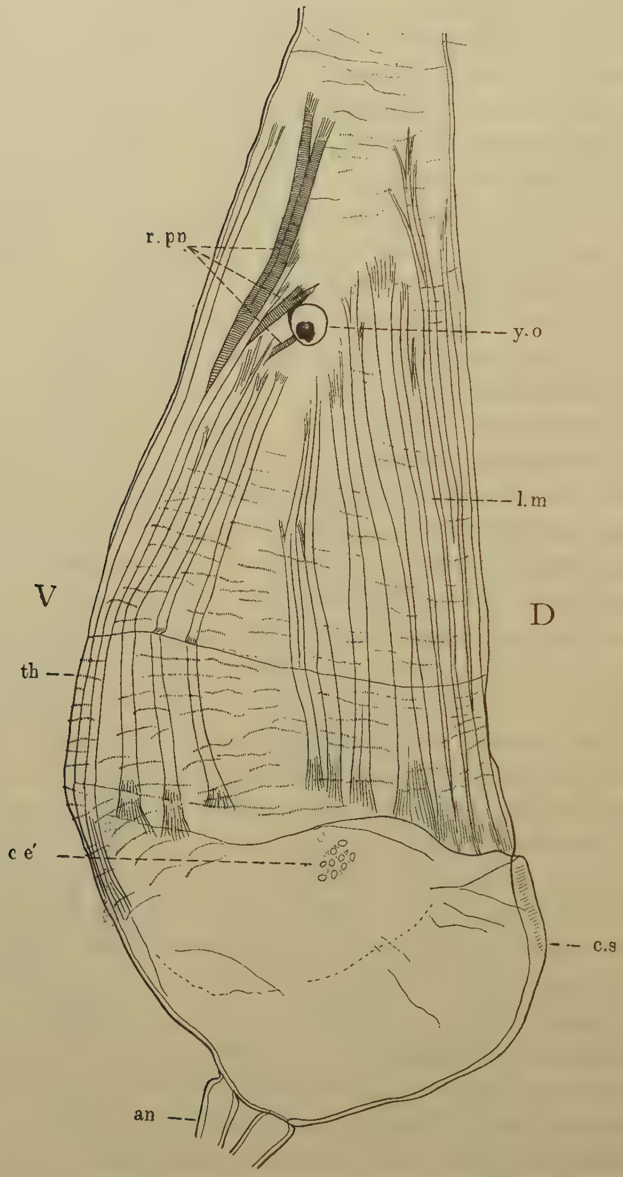

Fig. 10. Anterior portion of the male showing the external surface and longitudinal muscle layer, in lateral view. D—dorsal side, V—ventral side.
Other lettering as on p. 446. 〔×210〕

Genital Organ. Of the internal organs of the male, the genital organ is the most conspicuous, occupying almost the whole interior of the anterior portion. The condition of the gonad included within is exclusively of a male character. And the fact is just as it had been expected, there are indeed several highly characteristic features of the male organ that have been revealed in the males of other acrothoracicans as well as some Scalpellid cirripeds.

The male organ is ordinary in structure and consists of a single continuous tube which can be divided into four sections, the testis, vesicula seminalis, vas deferens and ductus ejaculatorius; the former three are situated in the connective tissue, while the last one is wholly enclosed within the sheath of the penis. The entire tract is considerably longer than the body (on an average twice as long), and therefore has a looped or winding course, which mode is peculiar to this form.

The testis (Figs. 11 and 12, *tes*) is situated in the center of the widest anterior portion and opens anteriorly, instead of posteriorly. It is a large globular or pyriform sac, measuring about 0.07–0.09 mm in diameter, and filled with compact mass of sexual elements which arise from the epithelial lining under the tunica propria. In moderately developed males, various developmental stages of the sexual cells may be met with, the spermatogonia (*spg*) occurring in the basal part (posteriorly to the body axis) and the spermatozoon (*spz*) in the portion leading into the vesicula seminalis. The spermatogonia are generally massed together, not diving into several groups such as shown in *Trypetesa* (after BERNDT). They are generally spheroidal in shape and as large as 5μ in diameter and enclose numerous chromatic substances; the nuclei could not be distinctly differentiated.

Successive developmental stages of the sexual cells up to the spermatozoon could not be followed out, but some of smaller cells more faintly stained with dyes are inserted—this is probably the spermatid stage. The spermatozoon is filiform, having a pinhead-like or pyriform head. Its proper length is not clear as it is too fine to be traced all the way.

The actual limit of the vesicula seminalis (*v.s*) which in most cases contains mass of thread-like spermatozoons is not strictly differentiated, since it is merely represented by a slight swelling at the place where it communicates with the testicular sac through gradual tapering, no distinct constriction such as shown in other acrothoracicans occurring between them. Thus, the vesicula seminalis is nothing but a dilation of the proximal part of the vas deferens. At this place the canal turns abruptly backwards and runs for some distance straightly. This part, answering the vas deferens (*v.d*) is a simple, narrow and empty duct, measuring about 10–15μ in diameter, and a little longer than one-fourth of the whole body. Cross section (Fig. 12A) shows that the wall consists of only a very thin cuticular tunica propria which is continuous throughout the canal; no epithelial cell could be detected.

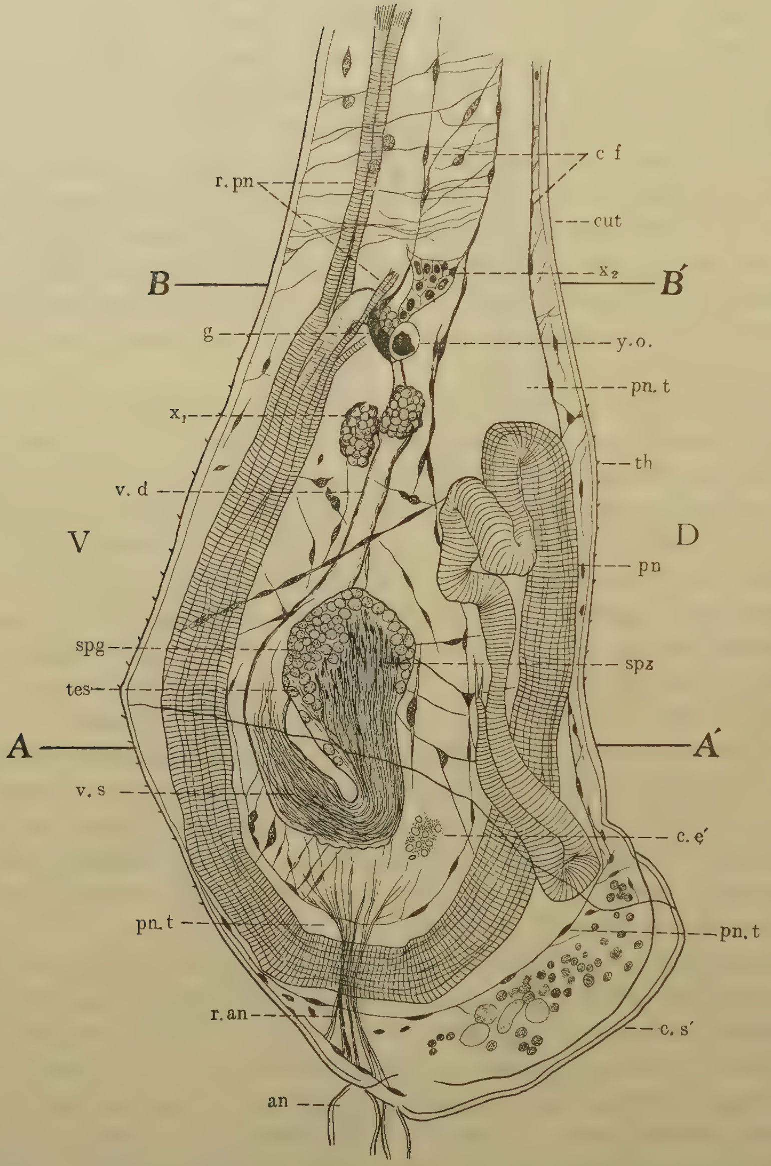
c f
r. pn
cut
B
x_2
B′
g
y.o.
pn. t
x_1
th
v. d
V
D
pn
spg
spz
tes
A
A′
v. s
c. e′
pn. t
pn. t
r. an
c. s′
an

Fig. 11. Anterior portion of the male showing the internal structure, in lateral view. A–A′, B–B′ represent the cutting levels of cross sections (A, B) given in Fig. 12.
Other lettering as on p. 446. [×210]

At the end of the vas deferens, where it is particularly narrowed, the canal turns back again towards the anterior extremity, and enters into the ductus ejaculatorius (*d.ej*) forming the penis. At the base of the penis there are several bundles of powerful striated muscles adhering at the their proximal ends to the connective tissue of the body; these muscles consist of two groups, one longer running longitudinally and the other shorter running obliquely. These muscles (*r.pn*) gather round the base of the penis and enter into the penis sheath to form together an outer circular layer of longitudinal muscles (*l.m.p*). Probably their commencements may act as the retractor in aiding the long prosbosciformed penis

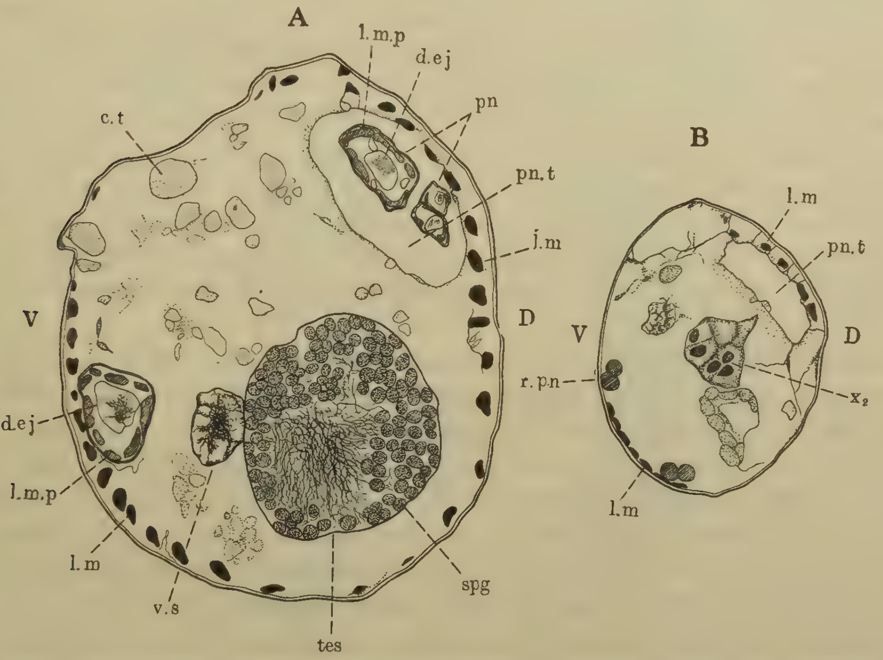

Fig. 12. A, transverse section of the anterior portion of the male, cutting along the line A–A′ shown in Fig. 11. B, transverse section of the median portion of the male, cutting along the line B–B′ shown in Fig 11.
Lettering as on p. 446. 〔×330〕

to withdraw itself into the body cavity, *i.e.* the penis-tube by their contraction. Similar retractor muscles or fibres are present in the allied *Trypetesa* and *Cryptophialus* too.

It is quite surprizing that the structure of the penis does not conform with that of other acrothoracicans described by earlier authors. The penis (*pn*) is of a remarkable length and greatly contractile; it starts from about the middle portion of the body, and runs forwards closely along the ventral surface of the body parallel to the foregoing genital tract. When it reaches the anterior extremity of the body, it turns backwards again forming a slight coil and then runs along the dorsal surface to the terminal end of the posterior prolongation. It runs freely within the channel-like body cavity throughout the whole length, except for its proximal portion on the ventral side where it passes through the connective tissue. The penis lies, as a rule, coiled up and entangled like an intestinal parasite within the widest portion of the channel-like body cavity named the penis-tube (*pn.t*), but even if stretched out, probably it does not attain the terminal end of the penis-tube, as inferred from its total length. In moderately stretched state the penis is approximately 0.1 mm in length and 0.03 mm in average diameter.

The penis is plainly annulated all over. It tapers gradually and terminates with a brush of few fine bristles. It is furnished with finely striated longitudinal muscles (*l.m.p*) arising from its base or extending from the retractor muscles at its base. These muscles consist of about as many as 10 bundles in the proximal portion, while fewer than 5 in the terminal portion. They form together with the ringed cuticular covering an outer sheath (*pn.s*) for the penis to enclose the ductus ejaculatorius within it. The ductus ejaculatorius (*d.ej*), which is a continuation of the vas deferens, is usually convoluted and attached at its end to the outer sheath. No other muscle such as the circular one is inserted between them (Fig. 13B).

In the males of *Trypetesa* and *Cryptophialus*, on the other hand, the penis is known to be furnished with circular muscles, and according to BERNDT (1903a), the retracter muscles lying at its base become weaker towards the penis and ultimately to form merely an outer layer of finer longitudinal muscle fibres. On this point attention should be called to the presence of an outer layer of strong longitudinal muscles in the penis of most ordinary cirripeds. In the ordinary group, the circular muscles, even when present, lie inside the layer of longitudinal muscles and are formed as the outer covering of the ductus ejaculatorius proper. Consequently I suspect the presence of such real circular muscles in the penis of *Trypetesa* and *Cryptophialus*. In this connection, it is noticeable that the longitudinal muscles around the body are non-striated in *Berndtia* as mentioned above, whereas, according to BERDNT, they are finely striated in *Cryptophialus*. Anyhow, it may deserve special notice that such opposed features as to the muscular system are seen between this form and other acrothoracicans.

Nervous System. The nervous system of the male is very simple, resembling that of *Trypetesa lampas*. In the middle portion of the body where the vas deferens communicates with the ductus ejaculatorius, there is a large dark-colored ganglion (*g*), which is usually lengthened parallel to the vas deferens. This ganglion corresponds well with the 'Hauptganglion' in *Trypetesa*. In the living state, it is purely black, but when preserved in alcohol or freshwater, it becomes paler and shows a purplish yellow hue. It varies much in outline from round to irregularly elongate (Figs. 13A and 14). In most cases, however, it appears to consist of two parts divided by a slight median constriction, of which the anterior part is almost round and the posterior one tapers distally. It is difficult to say the homology of this ganglion with that of the female, but from its shape I infer it to be fused mass of the ventral nerve ganglia. In fact, Kühnert (1934) recognizes from her embryological study of the male of *Trypetesa* the fact that the cerebral ganglia ('Gehirn') and ventral nerve cord ('Bauchmark') grow one after another and then become fused into a single mass at the cypris stage. Neither the optic ganglion nor the eye, which is known in the male of *Trypetesa*, is found at all, at least in the adult males. The histological structure differs little from that of any ganglion of the females which has already been described (*cf.* Utinomi, 1960, pp. 249–253).

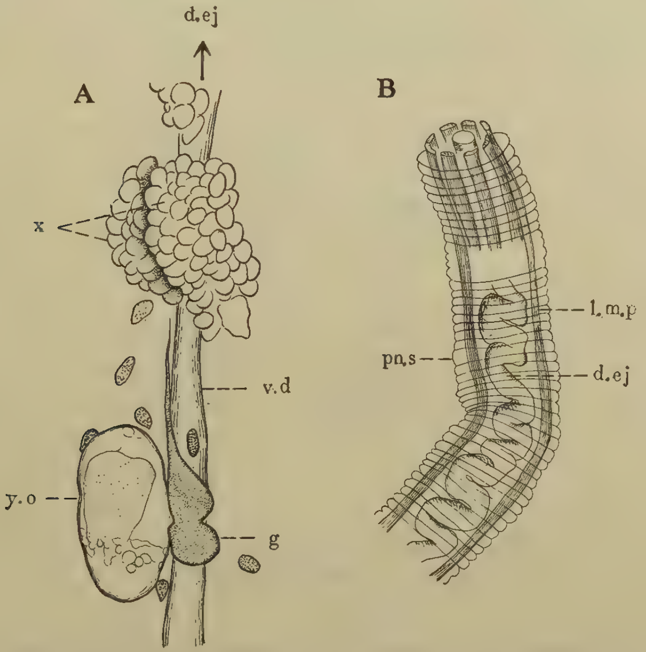

Fig. 13. A, vas deferens and its adjacent organs. B, a part of penis. Lettering as on p. 446. [×430]

Visceral Organs of Indistinct Nature. In total preparations I have always met with a large yellow peculiar body lying usually in close contact with the main ganglion (Fig. 13A, *y.o*). This is undoubtedly homologous with Aurivillius' 'gerundete Organ' or Berndt's 'rätselhaften gelbes Organ' found in the male of *Trypetesa lampas.*

This yellow organ (*y.o*) is usually round, measuring about 0.03–0.04 mm in diameter, and shows an orangish yellow hue. The content itself is apparently empty or structureless, but may be detected a thin sac-like area in the central part, not distinctly circumscribed. In the living state, the central part presents a rather dark purplish hue, so that it may mislead to be an eye or nerve ganglion, partly on account of being situated so close to the above-mentioned ganglion. However, when putting into alcohol or freshwater, the dark color becomes soon paler and even disappeared, and only remains a few yellowish granules in its marginal zone. The central part appears to be homogeneous and rather liquid-like or oily in nature, but not so fibrous as in *Trypetesa.*

As regards the nature of this organ, former authors have not given any clear interpretation. However, as suggested by AURIVILLIUS (1894), it reminds one of the 'gland of unknown nature' which has been discovered by HOEK (1884) in the male of *Scalpellum regium.* According to him, the 'gland' consists of two oval bags which are lined by an extremely delicate membrane and filled with brownish yellow granular substances; he considered it to be probably the remains of the appendages of the oesophagus. In the male of *Trypetesa,* KÜHNERT (1934) observed that the rudiment of the yellow organ has first appeared at the pupal stage, being placed near the main ganglion or brain. Anyhow, this yellow organ appears to be rudimentary, as compared with the other organs. However, even if so, it is more improbable to regard it merely as functionless, judging from the fact that it occurs throughout the whole life in the vestigial male alone. It seems to me that the yellow organ is somehow a kind of nutritive organ originated from the larval alimentary canal.

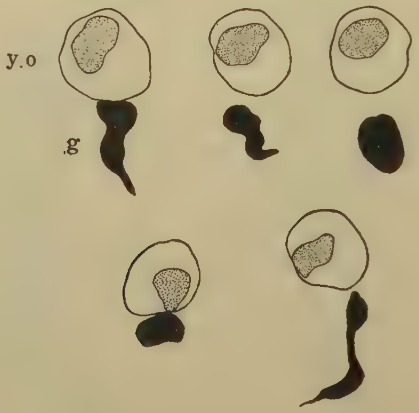

Fig. 14. Various shape of yellow organ (*y.o*) and nerve ganglion (g) of the male. [×210]

In the neighbourhood of the yellow organ as well as the main ganglion, there are found the other organs or cell-assemblages of indistinct nature (Figs. 11 and 13A). They consist of, in most cases, two or three groups, or which two

(x_1) are usually situated on either side of the vas deferens and the other one (x_2) situated posteriorly near the proximal end of the penis. Each of the anterior cell-assemblages is ovoid or globular, reminding of a mulberry fruit, and measures about 0.04 0.06 mm in longest diameter. The cells are spherical in shape and evenly granular in structure, without distinct trace of nuclei, and stained intensely with carmin. The posterior cell-assemblage is, on the other hand, generally irregular in outline and formed of large cells of irregular shape, each cell containing a large round nucleus in the middle. Judging from the general outline and structure, both cell-assemblages are probably of different kinds in nature.

These cell-masses have no direct communication between them and also with the other organs or lumen in the connective tissue. Such cell-masses are not found in any other acrothoracican. On comparison with the male of ordinary cirripeds, these remind somewhat of the 'cement glands', especially found in the males of *Scalpellum velutinum* and *S. regium*, which have been described and figured by Hoek (1883, 1884). As shown in Fig. 11, the position of these cell-masses in the present male is by far separated from the anterior end of the body where the antennules are situated. Hence it is not clear whether they are the same as the ordinary 'cement glands'. However, if such a question is not taken into consideration, the position of these bodies fairly corresponds with that of the 'cement glands' in the adult males of *Scalpellum*, as well as that of the 'Klebdrüse' (larval cement gland) in the cypris larva of *Trypetesa lampas*.

In the adult males of *Scalpellum*, such as *S. scalpellum*, *stroemi* etc., the 'cement glands' are generally situated at the same position as in the cypris stage; that is, they lie on both sides of the vestige of stomach and two ganglia in front of the testis (Krüger, 1940, p. 109). In *Trypetesa lampas*, the larval cement glands ('Klebdrüse') are, according to Kühnert, very developed in the cypris larva, but reduced to piecemeal vestiges and finally disappear entirely during the course of metamorphosis. She further states on this point that "Ich fand nur ein Exemplar, bei dieses Klebdrüse noch völlig intakt war.—Ob diese Klebdrüse der jugendlichen Zementdrüse gleichzusetzen ist, bleibt dahingestellt. Sie erfährt im Laufe der weiteren Entwicklung eine starke Rückbildung und verschwindet bei männlichen Tieren ganz. Diese spätere Zementdrüse unterscheidet sich wesentlich von diesem Organ durch Färbarkeit, Aufbau und Kleinheit der Kerne." In highly developed cypris larva of the female after 'Klebdrüse' disappeared, she discovered the rudiment of the cement glands of the adult stage around the anterior portion of the body.

In the connective tissue at the anterior extremity which lies between the external cuticle and genital tract, I have found also abundant mass of cellular elements in the adult male of this form. They are composed of round connective tissue cells, oil-drops and remains of yolk masses, all of which are variable in size and so confusedly scattered or grouped with one another that cannot be easily differentiated. All of them stain vigorously and uniformly with borax-carmin, rendering the examination of nuclei almost impossible. So it is very difficult to judge these cell-masses in the anterior portion as the rudiment of the cement glands of the adult stage, as KÜHNERT supposed. Nevertheless, it is not impossible to take the anterior globular bodies in question mentioned above for the vestiges of a pair of the larval cement glands. This supposition may be supported also by a comparison with the case of the Rhizocephala, in which the larval cement glands are said to be probably ultimately modified into the colleteric glands ('Kittdrüse') or reduced in the adult (FEUERBORN, 1931, 1933).

The other visceral organs, such as the digestive canal with its appendages and the excretory organs, are never found at all.

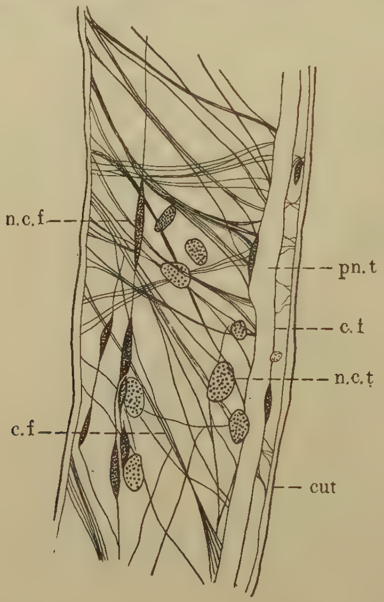

Fig. 15. A part of the posterior prolongation of the male. Lettering as on p. 446. [×410]

Connective Tissue and Penis Tube. The body is richly furnished with conspicuous connective tissue fibres forming a coarse network, and contains here and there transparent oil drops or yolk spherules abundantly. The connective tissue fibres lying in the posterior prolongation traverse obliquely and connect the penis tube (*pn.t*) lying close to the dorsal surface with the external cuticle (Figs. 9, 11 and 15). In addition, there are a few longitudinal fibres running parallel to the penis tube; they are, however, not continuous all throughout, but are formed of a number of short fibres connecting together at intervals in a single chain-like appearance (Fig. 15, *c.f*).

In the broad anterior portion, especially around the testis, the fibres are rather entangled and run in all directions to keep the genital tract in the middle. Of these fibres those lying at the base of the antennules are particularly strong and form a bundle; undoubtedly they may act as the retractor of the antennules (Fig. 11, *r.an*).

All these fibres are provided with large spindle-shaped nuclei. Mingled with such nuclei, there are found larger nuclei of different shape, lying freely in the connective tissue. They (*n.c.t*) are depressed, round to oval in outline and measure about 13μ in longest diameter. They contain vividly stained chromatic substances but apparently lack the nucleolus. The cell outline cannot be precisely differentiated (Fig. 11 and 15).

The penis tube, which contains the penis of extraordinary length, is the broadest in the coiled anterior portion and extremely narrow in the posterior prolongation. CALMAN (1909) regards the penis tube (in *Trypetesa*) as the vestige of the mantle cavity, However, as far as my observation on this *Berndtia* is concerned, it does not agree with the mantle cavity of ordinary cirripeds, since it is never lined by any cuticle nor by the epithelial cell layer, but only surrounded by a simple layer of delicate fibres which do not differ from those in the neighboring connective tissue. Moreover, it presents no indication of invagination of the external epithelium. Hence, the penis tube is nothing but a specialized lacunar channel in the body tissue. It is not homologous with the vestigial mantle cavity found in the males of Scalpelliform cirripeds, but peculiar to the group of Acrothoracica alone.

Terminal Sac or Ampulla. There remains to be described the terminal sac or ampulla (Fig. 8, *t.a*) which I have alluded to before. It projects at the dorsal surface of the terminal end of the body where the penis opens. It is considerably developed like a flask, consisting of a long stalk portion and an ellipsoidal head portion. It measures about 0.154 mm in total length and 0.055 mm in greatest diameter, the stalk being as long as the head or a little longer. It is lined with the somewhat thick cuticular epithelium and filled with the yellowish connective tissue containing abundant nuclei, somewhat granular in apperance. The nuclei within it are round to oval, somewhat depressed in outline and connected with one another by the finely fibrous structure. However, its interior apparently does not communicate with the penis tube nor with the exterior.

Such a peculiar appendage is not found in any other male of the Acrothoracica. Structurally it does not indicate any sign of glandular nature. However, judging from its position and peculiar feature and also from being fully developed even in the younget stage, it may be a kind of the tactile proboscis serving in the act of fertilization.

Summary

1. The results of my investigations on the larval development of *Berndtia*

purpurea UTINOMI and the detailed morphology of its male are here presented.

2. The embryo of the female first grows the bilobed median eye and then becomes to show the segmentation on the ventral side. The nauplius larva is identical with that of other acrothoracicans.

3. The youngest female first cannot bore itself into the coral skeleton till the mantle becomes wholly surrounded by the soft tissue of the host coral and then by the calcareous skeleton. In other words, after the formation of its own burrow and attachment-disc, the excavation actually takes place.

4. The males are exclusively attached to the wall of the female's burrow along the female's attachment-disc, usually 1 to 6 in association with a female. Its structure is characterized markedly by the coiled course of the whole genital organ and also by the presence of a peculiar terminal ampulla at the end of the posterior prolongation. No true mantle cavity is formed.

5. The male, as well as the female, probably lacks the metanauplius stage during the whole course of metamorphosis. The thoracic appendages such as present in ordinary cirripeds are not formed altogether during the metamorphosis.

6. The vestiges of naupliar swimming appendages still remain in the cypris stage, but are ultimately thrown off.

7. Both the nauplius- and cypris-eyes appear during the whole course of metamorphosis, but ultimately cast off with the cypris-sac.

8. The cypris-sac usually remains partially around the antennules even in the adult stage.

9. Neither the true mantle cavity nor the mantle-like covering is formed in the larval stages as in the adult. The male body is enclosed within a thin transparent membrane beneath the cypris-sac in the cypris stage, the membrane being closed and merely a remnant of the external cuticular covering of the thorax proper.

10. In short, the larval development of the female somewhat resembles that of *Trypetesa*, while the larval development of the male shows a closer resemblance to that of *Cryptophialus*.

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LIST OF ABBREVIATIONS USED IN THE FIGURES IN THE TEXT

a.att	Area of attachment.
a.pr	Attachment-process.
ab.s	Abdominal spine.
an	Antennule.
b	Body.
c_1	Cirrus I.
c.e′	Vestige of cypris-eye.
c.f	Connective tissue fibre.
c.l	Calcareous lamellae of coral.
c.s	Cypris-sac or -shell.
c.s′	Vestige of cypris-sac.
c.t	Connective tissue.
cor	Corium of coral.
cut	Cuticle.
D	Dorsal side.
d.ej	Ductus ejaculatorius.
e	Eye.
e.m	Egg membrane.
e.r	External ridge of operculum.
f.f	Frontal filament.
g	Main ganglion.
g.s	Supra-oesophageal ganglion.
h	Head.
i.r	Internal ridge of operculum.
l.h	Fronto-lateral horn.
l.m	Longitudinal muscle of mantle.
l.m.p	Longitudinal muscle of penis.
m	Mouth.
m.e	Median eye.
m.e′	Vestige of median eye.
m.f	Mesenterial filament.
n.c.t	Free nucleus in connective tissue.
o.d	Oil drop.
op	Operculum.
pn	Penis.
pn.s	Penis sheath.
pn.t	Penis tube.
r.an	Retractor of antennule.
r.c.e	Rudiment of cypris-eye.
r.c.g	Rudiment of larval cement gland.
r.pn	Retractor penis.
spg	Spermatogonia.
spt	Septum of coral.
spz	Spermatozoon.
t.a	Terminal ampulla.
ten	Tentacle of coral.
tes	Testis.
th	Thorn.
u.p.d	Upper projection of attachment-disc.
V	Ventral side.
v.a.p	Ventral thoraco-abdominal process.
v.d	Vas deferens.
vs	Vesicula seminalis.
v.s.a	Vestiges of naupliar swimming appendages.
x_1	Anterior enigmatic cell-assemblage.
x_2	Posterior enigmatic cell-assemblage.
y.o	Yellow organ.
y.s	Yellow substances.

RECORD OF AN UNUSUAL FISH STRANDING IN WINTER, WITH THE LIST OF STRANDED FISHES IDENTIFIED BY PROF. K. MATSUBARA

Takasi TOKIOKA
Seto Marine Biological Laboratory

With two Tables

Cold weather had continued for several days in the middle of February of this year and on the morning of the nineteenth, Sunday, I was alarmed by my boy, Takasi junior, who was much amazed at abundant fishes stranded on the beach near the laboratory on the way of his daily walk with his dog. It was very cold for this region; the thermometer stood at 0.2 Centigrade. He brought one of those fishes with him and I found it was *Fistularia petimba* Lacépède. Thinking that those fishes might be good as food for dog, my boy and I went down to the beach north of the laboratory and began to pick up fishes. At first, being interested in picking up fishes, I continued collecting, but soon I was impressed by so many kinds of those stranded fishes and changed my mind to continue collecting to examine fishes closely and record the event of the morning exactly, but not to secure much food for our dog. Now, my girl, Mié, was also called out for help and after an hour our buckets became enough heavy when we finished collecting along the beach of about 200 m long.

Being assisted by all hands of the family, the collected specimens were washed and sorted carefully. For most species, several of each species were sent to Prof. K. Matsubara of the Fisheries Institute of Kyoto University for examination, who identified them and gave me the list of fishes he examined. I want to express here my hearty thanks for his kindness in doing such things for me.

In all, about 1600 fishes belonging to 51 different species were included in the collection. Important specimens were presented to the ichthyological laboratory of the Fisheries Institute of Kyoto University and some to the Ôsaka Museum of Natural History, while others were tasted by my family members together with Mr. Genjiro Fukuda, the president of the publishing company known by the Illustrated Encyclopedia of the Fauna of Japan, or served as food for dog.

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1) Contributions from the Seto Marine Biological Laboratory, No. 377.

Publl. Seto Mar. Biol. Lab., IX (2), 1961. (Article 23)

Table 1. List of stranded fishes.

	Name	Maximum length	Number
1.	*Pterophryne histrio* (Linné) （ハナオコゼ）	13 cm	1
2.	*Antennarius sanguifluus* Jordan （ベニイザリウオ）	8.5 cm	1
3.	*Diodon holacanthus* Linné （ハリセンボン）		1
4.	*Fugu niphobles* (Jordan & Snyder) （クサフグ）	12 cm	1
5.	*Canthigaster rivulatus* (Temminck & Schlegel) （キタマクラ）	11 cm	5 (0.3%)
6.	*Canthigaster valentini* (Bleeker) （シマキンチヤクフグ）	10 cm	46 (2.9%)
7.	*Lactoria fornasini* (Bianconi) （シマウミスズメ）	8 cm	7 (0.4%)
8.	*Lactoria diaphanus* (Bloch & Schneider) （ウミスズメ）	12 cm	1
9.	*Apistus carinatus* (Bloch & Schneider) （ハチ）	10 cm	1
10.	*Pterois lunulata* Temminck & Schlegel （ミノカサゴ）	20 cm	3 (0.2%)
11.	*Palachaeturichthys polynema* (Bleeker) （ヒゲハゼ）	10 cm	1
12.	*Ptereleotris microlepis sakurai* (Schmidt) （サクライクロユリハゼ）	6 cm	71 (4.4%)
13.	*Vireosa hanai* Jordan & Snyder （ハナハゼ）	4.5 cm	1
14.	*Aspidontus maroubrae* (Ogilby) （クロスジギンポ）	4 cm	1
15.	*Chaetodon auriga* Forskål （トゲチヨウチヨウウオ）	6 cm	1
16.	*Pseudolabrus japonicus* (Houttuyn) （ササノハベラ）	4 cm	6 (0.4%)
17.	*Chromis notatus* (Temminck & Schlegel) （スズメダイ）	10 cm	25 (1.6%)
18.	*Pomacentrus coelestis* Jordan & Starks （ソラスズメダイ）	6.5 cm	5 (0.3%)
19.	*Chrysiptera assimilis* (Günther) （ルリスズメ）	4.5 cm	22 (1.4%)
20.	*Amphiprion xanthurus* (Cuvier) （クマノミ）	9 cm	6 (0.4%)
21.	*Champsodon snyderi* Franz （ワニギス）	4 cm	1
22.	*Brotula multibarbata* Temminck & Schlegel （イタチウオ）	31 cm	1
23.	*Jordanicus sagamianus* (Tanaka) （カクレウオ）		1
24.	*Leptoscolopsis nagasakiensis* Tanaka （イトタマガシラ）	6 cm	1
25.	*Franzia squamipinnis* (Peters) （キンギヨハナダイ）	4.5 cm	2 (0.1%)

Name	Maximum length	Number
26. *Grammistes sexlineatus proerythraeus* Fowler （ベニヌノサラシ）	6 cm	1
27. *Epinephelus megachir* (Richardson) （モヨウハタ）	7 cm	11 (0.7%)
28. *Epinephelus fasciatus fasciatus* (Forskål) （アカハタ）	7 cm	1
29. **Acropoma japonicum* Günther （ホタルジャコ）	5.5 cm	37 (2.3%)
30. *Apogon niger* Döderlein （クロイシモチ）	9 cm	213 (13.2%)
31. **Apogon eliotti* Day （ツマグロイシモチ，シチセンイシモチ）	10 cm	18 (1.1%)
32. *Apogon teniatus* Cuvier （ヨコスジイシモチ）	12 cm	50 (3.1%)
33. *Apogon schlegeli* Bleeker （コスジイシモチ）	9.5 cm	669 (41.6%)
34. *Apogon döderleini* Jordan & Snyder （オオスジイシモチ）	9.5 cm	30 (1.9%)
35. *Apogon kiensis* Jordan & Snyder （テツポウイシモチ）	5.5 cm	5 (0.3%)
36. *Apogon semilineatus* Temminck & Schlegel （ネンブツダイ）	8 cm	7 (0.4%)
37. *Apogon notatus* (Houttuyn) （クロホシイシモチ）	8.5 cm	167 (10.4%)
38. *Apogon erythrinus kominatoensis* Ebina （コミナトイシモチ）	4.5 cm	11 (0.7%)
39. *Pempheris japonicus* Döderlein （ハタンポ）	4.2 cm (total length)- 4.7 cm (head length)	3 (0.2%)
40. *Leiognathus elongatus* Smith & Pope （ヒメヒイラギ）	4.4 cm	1
41. *Holocentrus spimo*-sisimus Temminck & Schlegel （イツトウダイ，カノコウオ）	11 cm	1
42. **Paratrachichthys prosthemius* Jordan & Fowler （ハリダシエビス）	5.5 cm	1
43. *Fistularia petimba* Lacépède （アカヤガラ）	95 cm	153 (9.5%)
44. *Gymnothrax hepatica* (Temminck & Schlegel) （ヘリシロウツボ）		1
45. *Leiuranus semicinctus* (Lay & Bennett) （ソラウミヘビ）		1 (on Feb. 20)
46. *Anago anago* (Temminck & Schlegel) （ゴテンアナゴ）	22 cm	1
47. *Conger cinereus* Rüppell （クロアナゴ）		1
48. *Rhynchocymba nystromi nystromi* Jordan & Snyder （ギンアナゴ）		2 (0.1%)
49. *Uroconger lepturus* (Richardson) （アイアナゴ）		1
50. *Echelus uropterus* (Temminck & Schlegel) （ヒレアナゴ）		1
51. *Plotosus anguillaris* Lacépède （ゴンズイ）		10 (0.6%)
		1609 in total

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* with luminous organ.

As I had noticed that a large angler fish, *Antennarius scriptissimus* JORDAN, and a kind of porcupine fishes, *Chilomycterus affinis* GÜNTHER, had been stranded on the same beach since a few days before, it is clear that those fishes were killed by cold and gathered there by gentle north west wind on that Sunday morning.

Table 2. Water temperature in the middle of February, 1961.

Date	t°C	Date	t°C
12	13.48	16	11.50
13	13.00	17	11.69
14	12.59	18	11.59
15	11.00	19	11.48

RECORD OF WORKS
DONE AT THE SETO MARINE BIOLOGICAL LABORATORY

1958（昭和33年）

Contribution
No. (Jap. No.)

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